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Gas-Steam Unit Shows 72.4 Per Cent Thermal Efficiency at Ford Works

By L. D. Royer
Power-Construction Department, Ford Motor Company

Results from one-hour test show thermal efficiency based on high heat value of gas of 23.1 per cent for gas-engine cylinders and heat recovery from exhaust gases of 49.3 per cent, giving total thermal credit of 72.4 per cent. On steam-engine cylinders a thermal efficiency of 20.4 per cent, made possible by hot exhaust gas jacketing. Over-all thermal efficiency of unit 17.3 per cent. Combined mechanical efficiency of unit, 79.2 per cent.

SINCE the adoption of the "gas-steam" unit as a prime mover for electrical generation by the Ford Motor Co., the mammoth engines employed have been of great interest to engineers. After inquiries as to design and the general layout of the unit had been satisfied, there still remained leading questions relating to over-all efficiency and the percentage of waste heat recovered. Data of this character were never available until recently, and while results given herewith were obtained from tests under operating conditions somewhat below normal, they will serve to give a fair indication of the economies that may be credited to these units.

In back issues of *Power* a description of the Highland Park Plant and details of engine design have been given.* Briefly, these units consist of a horizontal twin engine with tandem gas-engine cylinders on one side and tandem compound-steam cylinders on the other, driving a 4,000-kw. direct-current generator at 80 revolutions per minute. Full dimensions of the unit are given in Table I.

Valves on the high-pressure steam cylinder are of the poppet type, and Corliss valves serve the low-pressure cylinder. The one unique feature on the steam side is the circulation of a portion of the exhaust from the gas engine through a jacket surrounding the high-pressure steam cylinder. In this way about 2.5 per cent of the total heat supplied to the gas engine is recovered and converted into useful work.

On the gas-engine side the cooling involves four distinct systems—the cylinder jackets, the exhaust manifold or jacketed tees, the piston and the valve boxes. The exhaust manifold and the piston use cooling water after it has passed through the steam condenser and deliver it to the factory to be used in process work. Water passing through the cylinder jackets is used as boiler feed, and that supplied to the valve boxes is cold city water, which is not further utilized. From the foregoing it will be seen that a considerable amount of

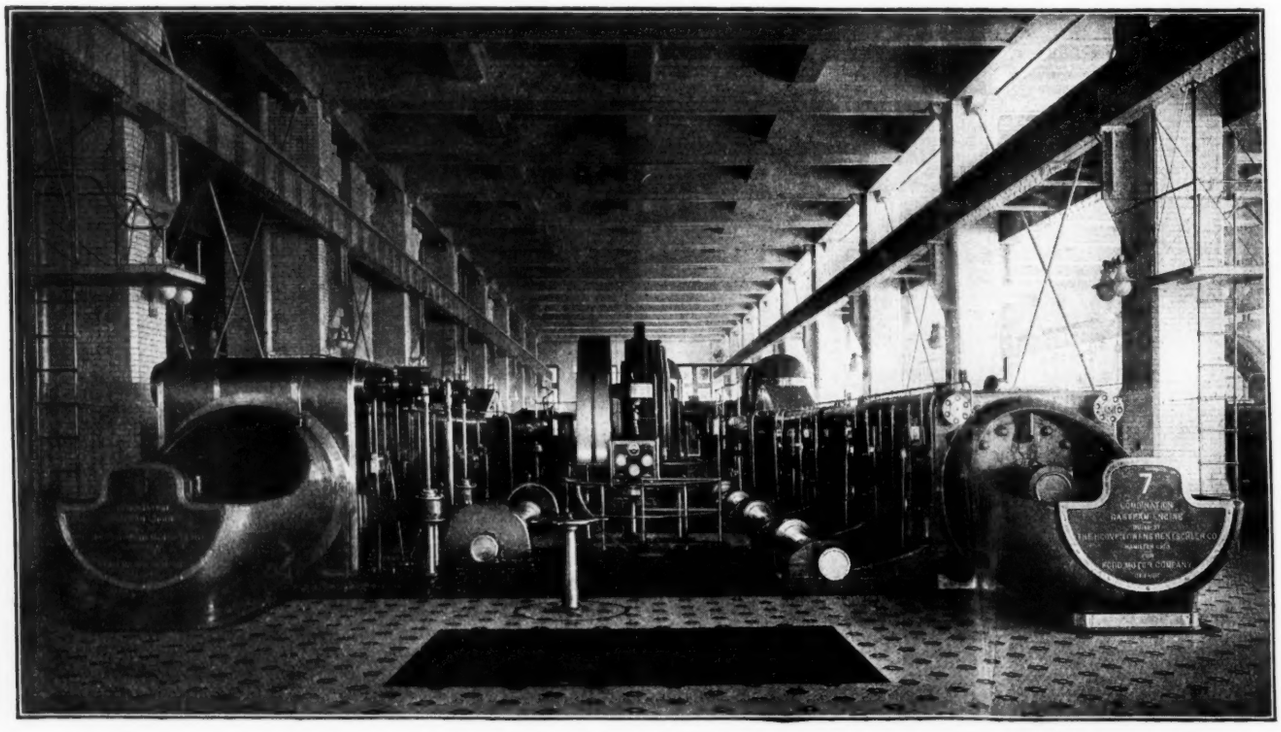

FIG. 1. COMBINATION "GAS-STEAM" UNIT AT THE PLANT OF THE FORD MOTOR COMPANY

*Nov. 21, 1916 and Jan. 16, 1917.

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heat is recovered. When proper thermal credit is given, it will be apparent that these engines, in addition to delivering current to the busbars at relatively high efficiency, will show economies far beyond the average condensing plant.

If considered in the terms of the indicated horsepower delivered, the gas-engine performance is not exceptional, but when operated in connection with a steam plant, as well as a manufacturing plant using hot water in production, great economy results, due to the fact that a considerable portion of the heat in the exhaust gases is utilized. The test shows that 20.7 per cent of the total heat supplied to the gas engine is recovered in the cylinder-jacket cooling water, and 23.1 per cent is recovered from the piston and exhaust manifold, the water being used for metal washing and other manufacturing processes throughout the factory at a temperature of 140 to 150 deg. The items previously enumerated, together with the 2.5 per cent supplied to the steam cylinder and 21.7 per cent converted into work in the cylinders, shows a total thermal credit of 68 per cent for the gas engine, based on the high heat value of the gas supplied; based on the low heat value, the thermal credit would be 72.4 per cent.

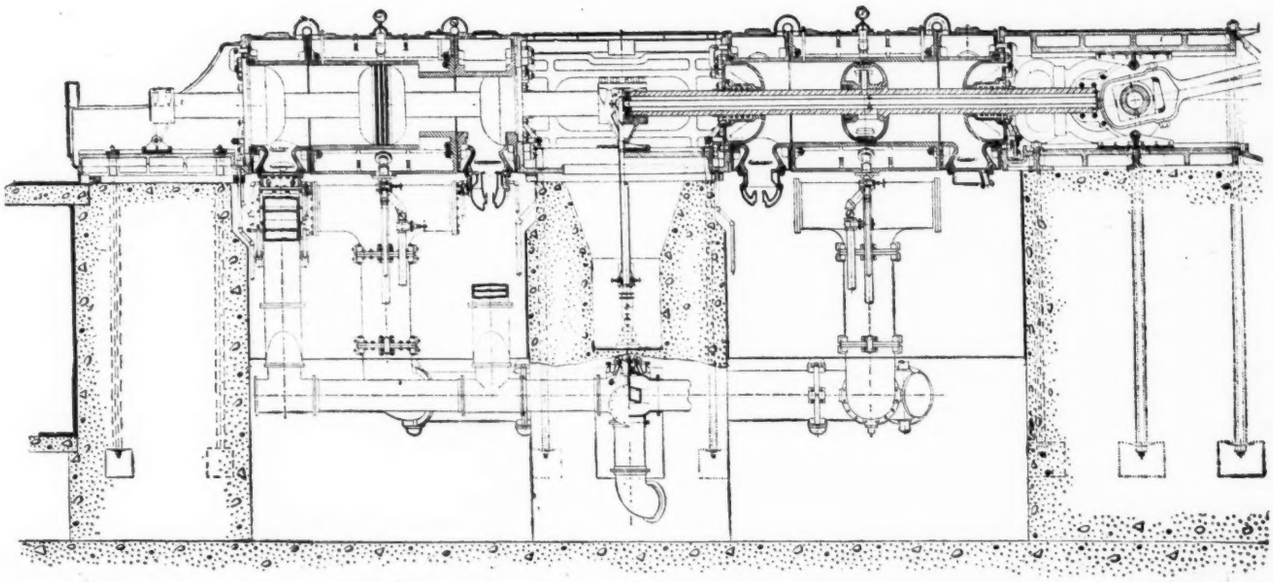


FIG. 2. LONGITUDINAL SECTION THROUGH GAS ENGINE CYLINDERS

Gas is supplied by an up-to-date producer plant, consisting of 22 sections of Smith producers burning coal, three Hughes producers burning coal and four Hughes producers burning coke. The total hourly capacity of the plant is 1,500,000 cu.ft. of gas with an average calorific value of 162 B.t.u. per cubic foot. The total cost of producing gas and delivering it to the engine is ten cents per thousand cubic feet.

Steam is supplied by a boiler plant of 13,300 hp. in water-tube boilers, delivering steam to engines at 150 lb. pressure and 60 deg. superheat. The boiler room is up to date in every respect and is equipped with automatic coal-handling devices and all appliances for the economical production of steam. The cost of steam at this time is 35 cents per thousand pounds.

With gas containing 162 B.t.u. per cu.ft. and costing $0.10 per 1,000 cu.ft., for $1 a total of 1,620,000 B.t.u. is furnished. With steam containing 1,126 B.t.u. per lb. above the temperature of the condensate and costing $0.35 per 1,000 lb., $1 will supply 3,217,000 B.t.u. However, as shown by test, 68 per cent of the heat in the gas, or 1,101,600 B.t.u. is converted into useful work, while by the same test 20.4 per cent of the heat in the steam, or 656,270 B.t.u., is utilized. Thus the relative cost of the heat converted into useful work by the gas and the steam sides is at 1: 1.68.

The problem of securing accurate data on the steam side of the unit presented no special difficulties, standard test gages, thermometers, calorimeters, mercury col-

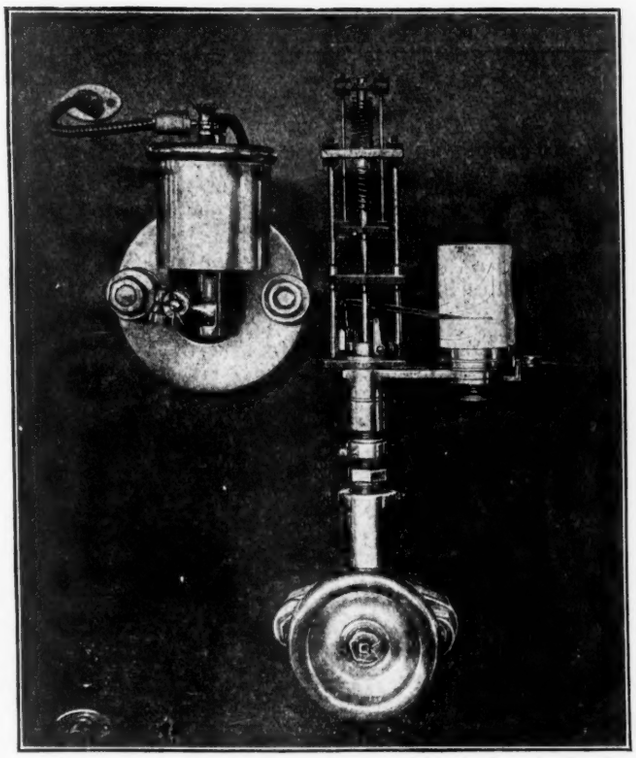


FIG. 3. DOUBLE-SPRING INDICATOR FOR USE ON GAS CYLINDERS

umns and indicators being available; likewise with the measurement of the electrical output accurately calibrated ammeters and voltmeters being used. However, to determine the distribution of heat in the gas cylinders, some special apparatus worthy of mention was necessary; namely, the Orr gas-engine indicator designed by William Orr, operating engineer at the Highland Park Plant.

Referring to Fig. 3, it will be seen that this indicator has a combination of two springs. It uses a 180-lb. spring during the compression and explosion periods and a 10-lb. spring on the scavenging and suction strokes. By referring to the diagram produced by this indicator (Fig. 4), the advantage of this simple and unique feature is obvious.

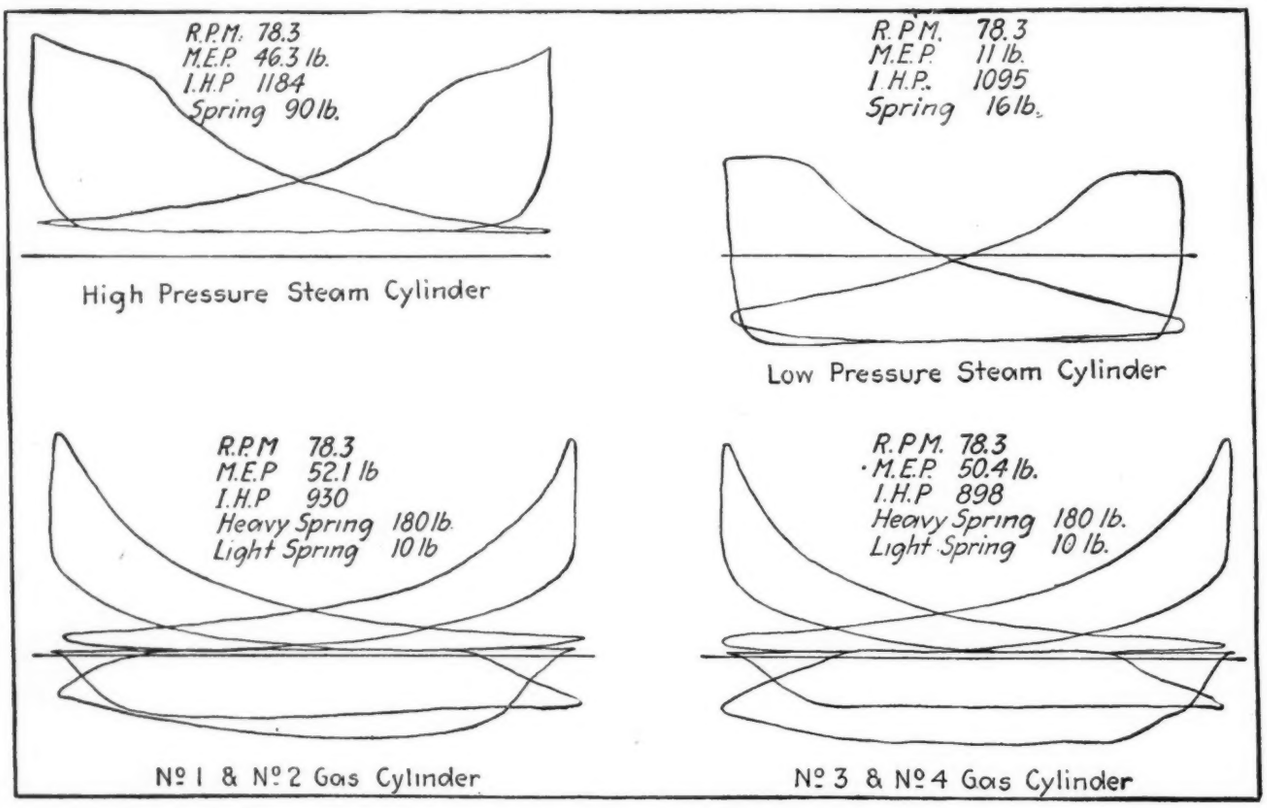


FIG. 4. INDICATOR DIAGRAMS FROM STEAM AND GAS ENGINE CYLINDERS

During the test the quantities of gas and water were determined by a special type of pitot tube which had been carefully calibrated, and constants had been previously determined. By this method the gas at any temperature and pressure could be accurately measured and the flow of water at any temperature determined. While the pitot tube is not recognized as the best instrument for accurate measurements, tests made with standard meters in parallel gave readings that were practically identical.

In Table II is given the results of a one-hour test selected from a number of similar runs. The test was taken and computed in accordance with the standard A. S. M. E. Code. The figures speak for themselves. It might be well to point out that the particular high efficiency of 20.4 per cent for the steam cylinders was due in part to the circulation of hot exhaust gas through the high-pressure cylinder jacket, thereby eliminating cylinder wall condensation. On the other hand, the tests were run at a time when both steam and gas plants were inadequate to care for the constantly increasing load, so that steam was being generated at 150 lb. gage, 30 lb. under normal, and on account of a shortage of gas resulting in a reduced pressure in the main, the gas engine cylinders were developing only 1,828 hp. instead of the full normal rating of 2,750 hp. At full load the gas-engine cylinders in particular should have shown a higher thermal efficiency. However, the economy under average operating conditions at the time of the test was the information sought, and the results are given for what they may be worth.

TABLE I—DIMENSIONS OF COMBINATION "GAS-STEAM" UNIT

Steam Engine

Type	Tandem compound
Auxiliaries	Electric driven
Rated horsepower	2,750
High-pressure cylinder diameter, in.	36.25
Low-pressure cylinder diameter, in.	68.00
Stroke of pistons, in.	72.00
Diameter of piston rod, in.	13.00
Clearance Hp. Cylinder:	
Head-end, per cent piston displacement	8.47
Crank-end, per cent piston displacement	8.45
Hp. Constants (1 lb. Pressure, 1 rev.):	
High-pressure cylinder	0.327
Low-pressure cylinder	1.2723

Gas Engine

Class:	
(a) Four cycle.	
(b) Make-and-break ignition, 110 volt, direct-current.	
(c) Two cylinders, double-acting.	
(d) Straight line arrangement of cylinders.	
(e) Horizontal.	
Diameter of cylinders, in.	42
Stroke of pistons, in.	72
Rated horsepower	2,750
Fuel	Producer gas
Horsepower constant (1 lb. pressure, 1 rev.)	0.1139

Generator

Type	Direct Current, Compound Wound
Capacity at 80 r.p.m, kw.	4,000
Volts	250

TABLE II—RESULTS OF TEST ON LARGE "GAS-STEAM" UNIT

Steam Engine

Run number	2
Duration, hr.	1
Exhaust gas through high-pressure cylinder jacket, per cent.	20
Average Pressures and Temperatures	
Pressure in steam pipe near throttle, lb. gage	146.0
Barometric pressure, in. of hg.	29.57
Pressure of steam entering l.-p. cylinder, lb. gage	17.0
Vacuum in condenser, in. hg.	24.2
Temperature of steam near throttle, deg. F.	423.5
Superheat in steam near throttle, deg. F.	59.6
Quality of steam leaving h.-p. cylinder, per cent.	96.7
Quality of steam entering low-pressure cylinder, per cent.	96.7
Quality of steam leaving low-pressure cylinder, per cent.	89.0
Temperature of condensate, deg. F.	104.0
Hourly Quantities	
Dry steam consumed by engine per hour, lb.	24,054
Heat units given to engine by steam per hr., B.t.u.	27,849,475
Heat units added by jacket gas per hour, B.t.u.	545,935
Heat units consumed by engine per hour, B.t.u.	28,395,410
Power	
Revolutions per minute	78.3
Indicated horsepower developed by steam engine	2,279
Indicated horsepower developed by h.-p. cylinder	1,184
Indicated horsepower developed by low-pressure cylinder	1,095
Economy Results	
Dry steam consumed by engine per i.hp. per hr.-lb	10.6
Heat units given engine by steam per i.hp. per hr., B.t.u.	12,220
Heat units added by jacket gas per i.hp. per hr., B.t.u.	240
Heat units consumed by engine per i.hp. per hr.	12,460
Efficiency Results	
Thermal efficiency, based on i.hp., per cent.	20.4

Gas Engine

Run number	2
Duration, hr.	1
Average Pressures and Temperatures	
Pressure gas in main near engine, in. water	0.42
Temperature of room, deg. F.	0.76
Temperature of gas entering superheater, deg. F.	808
Temperature of gas entering steam cyl. jacket, deg. F.	732
Temperature of gas leaving steam cyl. jacket, deg. F.	465
Temperature of gas to exhaust from superheater, deg. F.	676.5
Temperature of cylinder jacket water inlet, deg. F.	107.3
Temperature of head-end cyl. jacket water outlet, deg. F.	174.5
Temperature of crank and cyl. jacket water outlet, deg. F.	178.8
Temperature of piston cooling water inlet, deg. F.	94
Temperature of piston cooling water outlet, deg. F.	140.3
Temperature of jacketed tee water inlet, deg. F.	94
Temperature of jacketed tee water outlet, deg. F.	139.2
Relative humidity, per cent	89
Calorific value of gas per cu.ft., high value, B.t.u.	152.8
Calorific value of gas per cu.ft., low value, B.t.u.	143.5
Hourly Quantities	
Quantity of producer gas supplied, cu.ft.	140,456
Quantity of air supplied, cu.ft.	242,076
Quantity of air and gas supplied, cu.ft.	382,532
Heat units consumed by engine per hr., low ht. value, B.t.u.	20,162,459
Heat units consumed by engine per hr., high ht. value, B.t.u.	21,461,677
Cooling water supplied to head-end jacket, lb.	32,518
Cooling water supplied to crank-end jacket, lb.	31,535
Cooling water supplied to pistons, lb.	56,457
Cooling water supplied to jacketed tees, lb.	52,054
Analyses	
Analysis of Producer Gas by Volume:	
CO_2, per cent	5.53
CO, per cent	27.0
H_2, per cent	12.9
CH_4, per cent	1.97
N_2, per cent	52.6
Analysis of Exhaust Gas by Volume:	
CO_2, per cent	14.9
O_2, per cent	4.0
N_2, per cent	81.1
Power	
Indicated horsepower	1,828
Economy Results	
B.t.u. consumed by eng. per i.hp. per hr., low ht. value	11,030
B.t.u. consumed by eng. per i.hp. per hr., high ht. value	11,741
Efficiency Results	
Thermal efficiency gas eng. cyl., i.hp., high ht. value, per cent	23.1
Thermal credit based on i.hp. plus heat recovered, per cent	72.4
Volumetric efficiency, per cent	78.0

Heat Balance—Low Heat Value

Based on B.t.u. per i.hp. per hours	B.t.u.	Per cent
Heat converted into work	2,545	21.7
Heat recovered in jacket cooling water	2,429	20.7
Heat recovered in piston cooling water	1,430	12.2
Heat recovered in jacketed tee cooling water	1,287	10.9
Heat rejected in superheater, radiation	419	3.6
Heat recovered in steam cylinder jacket	299	2.5
Heat rejected in exhaust	2,949	25.1
Heat rejected in valve box cooling water	328	2.8
Heat unaccounted for, including radiation	55	0.5
Total heat consumed per i.hp. per hour	11,741	100

Distribution of Heat Recovered from Exhaust Gas

	B.t.u.	Per cent
Jacket cooling water used for boiler feed	2,429	20.7
Jacket tee cooling water used for factory service	1,287	10.9
Piston cooling water used for factory service	1,430	12.2
Heat recovered in high press. steam cyl. jacket	299	2.5
Total	5,445	46.3

TABLE II—RESULTS OF TEST ON LARGE "GAS-STEAM" UNIT—(Concluded)

Data on Complete Unit

Total i.hp. developed	4,107
Mechanical and electrical losses, hp	858
Electrical horsepower developed	3,249
Combined mech. and elec. eff., per cent	79.2
Overall thermal efficiency = Ht. equiv. of a kw.-hr. at sw. bd. / Ht. supplied to unit per kw.-hr.	17.3
Water Temperatures	
Water through head-end cylinder jacket, g.p.m.	65
Water through crank-end cylinder jacket, g.p.m.	63
Water through pistons, g.p.m.	113
Water through jacketed tees, g.p.m.	104
Water through each valve box, g.p.m.	7
Temperature of cylinder jacket water inlet, deg. F.	107
Temperature of head-end cylinder jacket water outlet, deg. F.	174
Temperature of crank-end cylinder jacket water outlet, deg. F.	179
Temperature of piston cooling water inlet, deg. F.	94
Temperature of piston cooling water outlet, deg. F.	140
Temperature of jacketed tee water inlet, deg. F.	94
Temperature of jacketed tee water outlet, deg. F.	139
Temperature of valve box cooling water inlet, deg. F.	94
Temperature of valve box cooling water outlet, deg. F.	130
Gas	
Quantity of producer gas supplied, cu.ft. per hr.	140,456
Quantity of air supplied, cu.ft. per hr.	242,076
Quantity of air and gas supplied, cu.ft. per hr.	382,532
Steam	
Pressure of steam near throttle, lb. gage	146
Pressure of steam entering one piston cylinder, lb. gage.	17
Vacuum in condenser, in. hg.	24.2
Superheat in steam near throttle, deg. F.	59.6
Quality of steam leaving hp. cylinder, per cent	96.7
Quality of steam leaving low-pressure cylinder, per cent.	89
Dry steam consumed by engine per i.hp. per hr., lb.	10.6
Efficiencies	
Thermal efficiency steam engine, based on i.hp., per cent.	20.4
Thermal efficiency gas engine, based on i.hp., per cent.	23.1
Thermal credit gas engine, based on i.hp. plus heat recovered, per cent	72.4
Volumetric efficiency gas engine, per cent	78
Combined mechanical and electrical efficiency, per cent.	79.2
Combined thermal efficiency based on hp. delivered, per cent	17.2

Multiple-Stage High-Pressure Turbine Pumping Set

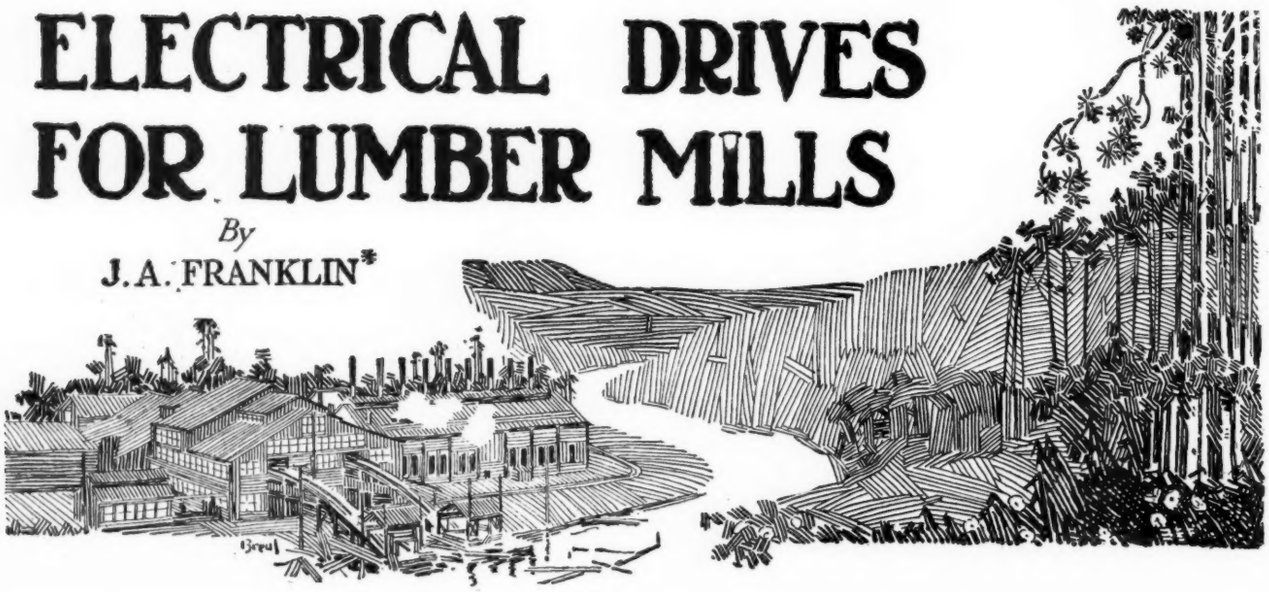
Multiple-stage turbine pumps are built with as many as ten impellers in series, and in cases in which that maximum does not give the pressure required at the given speed it is usual to mount two such pumps on one bed-plate, the two units being connected in series so that the resulting pressure will be that due to as many as twenty impellers in series. A pump that has been designed for a working pressure of 1,500 lb. per sq. in. or 3,470 ft. head of water at a speed of 1,480 r.p.m. has been built by Mather & Platt, Ltd., Manchester, England, says *The Engineer*. It has a capacity of 800 gal. per minute and is driven by a 1,450-hp. electric motor. The guaranteed efficiency of the pump is 68 per cent, and the actual horsepower required to drive it at full load is 1,240.

The low-pressure pump has six stages and develops 1,486 ft. head; the high-pressure pump has eight stages and develops 1,984 ft. head, or a total of 3,470 ft. The low-pressure pump is made with as few stages as possible in order to keep the pressure on the stuffing-boxes on the high-pressure pump as low as possible. Notwithstanding this, there is a pressure of 650 lb. per sq.in. on these boxes, but owing to the arrangement of the packing adapted, the boxes run cool. They are fitted with metallic packing.

The over-all length of the complete set is 31 ft. 3½ in., height 5 ft. 5½ in., and the over-all width 6 ft. 7½ in. The motor is designed for three-phase 50 cycle current at a pressure of 6,600 volts. The pump's suction pipe is 9 in. and on the delivery side the pipe is 8 in. in diameter.

ELECTRICAL DRIVES FOR LUMBER MILLS

By
J. A. FRANKLIN*



Factors that have influenced the application of electricity to the lumber industry are discussed, then the sizes, types and characteristics of the motors used to drive the various machines in lumber mills are treated of. The sizes and types of motors and methods of driving are summarized in a convenient table.

ACTUATED by an enormous demand for timber of various kinds during the last few years, the lumber industry, in common with many other American activities, has made rapid strides in the improvement of production methods. Satisfactory operation in the largest lumber mills has shown that electric motors easily take care of the requirements of log hauls, band mills, edgers, etc. Nearly all new mills are fully equipped with electric drives, and furthermore, a large number of old ones are being converted from mechanical to electric drives. As the prime essential of lumber mills is reliability, operations demand equipment upon which dependence can be placed. Employees are constantly impressed with the idea of getting lumber through the mills in the shortest time possible, and too frequently the machines are given little consideration, therefore any apparatus intended for this application must be designed to withstand the hardest kind of usage.

The danger from fire is greatly reduced when electricity is used, because there are fewer bearings to be filled with oil, which is frequently spilled on the bridge trees and posts supporting the bearings. There is also less fire hazard owing to the elimination of shafting, belting and bridge trees, with the accompanying walks and platforms built to enable the millwrights and oilers to get to and from the machinery. The floor of the mill becomes a much clearer space, where a fire may not only be detected more readily, but possibly checked once it has started, a fact that is always taken into consideration by the insurance companies when making a rate.

Naturally, the problems of electrifying are as varied as there are mills, but in general the same types of motors are used for driving the same types of machines. The motor sizes for the various machines depend on the local conditions in any particular mill.

Alternating current is used almost exclusively, because sparking and consequent fire hazard are reduced to a minimum and because the power-distributing problems are simplified, especially when the mill is scattered over a large territory.

Two types of alternating-current motors are used in the lumber industry—the squirrel-cage and wound-rotor. Squirrel-cage motors are generally used where very high starting torque is not required and variable speed is unnecessary. The rotating element presents a sturdy and reliable piece of apparatus, and the only attention required is an occasional oiling of bearings. In addition, the controller, manually or automatically operated, used for starting and stopping or reversing the motor is simple in construction and easy to operate.

There are many instances, of course, where the squirrel-cage motor is not suitable and a wound-rotor type must be used. This is usually the case when the machine starts under a very heavy load or must operate at variable speeds. The starting, stopping, reversing or speed changing of the motor can be either manually or automatically controlled. Speed variation in this type of motor results from changing the external resistance in the windings of the rotating element; the greater the resistance the slower the motor speed. The following gives an outline of the types of motors required on the various machines and their characteristics. An analysis of these data is given in the table.

Having been brought from the woods to the mill, the logs are unloaded into the log pond. They are generally conveyed from the pond into the mill by means of the familiar log haul, or in some mills by a log lift. In the case of the log haul an endless bull chain with hooks or "dogs" spaced every few feet runs in a steel groove up an incline from the pond to the log deck, at a speed of from 45 to 180 feet per minute. The most satisfactory method of drive, and one that has been generally adopted, is the installation of a wound-rotor motor of from 25- to 50-hp. rating with a drum controller, the motor being started and stopped whenever it is desired to start or stop the bull chain.

Another method of drive sometimes applied to the haul is a constant-speed squirrel-cage motor, in which

*Industrial Department, Westinghouse Electric and Manufacturing Company.

case the motor operates continuously and the load is thrown on and off by means of a clutch or friction. In either case the motor is generally connected to the driving sprocket through reduction gears in order to produce the desired speed of the bull chain.

Where the log lift is employed, the logs are floated alongside the mill by means of a pond or canal, and cables are used to lift them to the deck. One end of each cable is attached to the edge of the deck and the other ends are secured to drums, thus permitting the cable to sag into the pond, forming a loop into which the logs are floated. A variable-speed wound-rotor motor of from 35- to 50-hp. capacity is geared to the drum, and as the latter revolves, the slack of the cables is taken up and the logs are rolled up inside of the loop on to the deck. The motor is generally equipped with a solenoid brake so as to enable it to hold the load suspended at any point in case for some reason it is necessary to stop its progress.

After the logs arrive on the deck, they are placed on the log carriage. The control valves for the "kickers" and loaders, as well as practically all the steam and air cylinders throughout the mill, are operated by electromagnets controlled by push-buttons, which may be placed at any convenient points and operated either by foot or by hand as may be desired. The set-works on the carriage used to adjust the position of the log for the saw cut are of the type that requires rotating motion and are most satisfactorily driven by a constant-speed squirrel-cage motor of from 5- to 10-hp. capacity. The motor operates continuously and is supplied with current from a flexible cable or from a trolley suspended from the side of the mill, preferably the latter. The motor may be direct-connected, geared, belted or chain-driven.

The rock saw used in some sections of the country, which precedes the main saw, cutting a path through

FIG. 1. ELEVEN-FOOT ELECTRICALLY OPERATED BAND MILL

the bark, removing any rock, gravel or other matter likely to injure the main-saw teeth, is mounted above the carriage on a framework that can be raised and lowered by the operator. It is driven by a 10- or 15-hp. squirrel-cage motor, mounted on the upper portion of the framework and belted to the saw. The motor runs continuously and is controlled by an auto-starter installed near the head sawyer's stand. A motor-driven blower is generally provided to carry away the sawdust. The head saw, Fig. 1, is generally of the band type and requires the largest motor used in a mill—from 100- to 300-hp. capacity. For driving the bandsaw a wound-rotor motor is recommended because of the heavy starting torque required due to the inertia of the saw and the wheels over which it runs. A high-speed three-bearing motor is generally belted to the driving

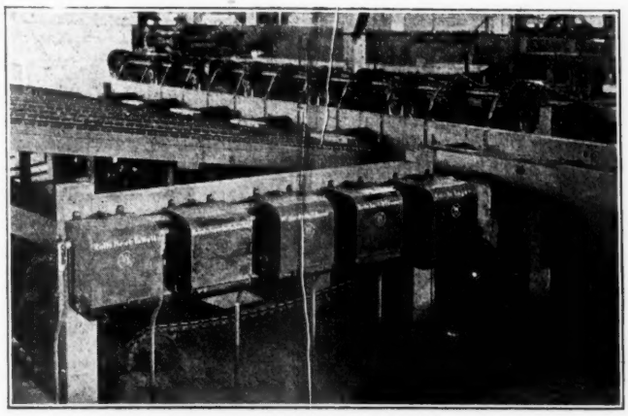


FIG. 2. INSTALLATION OF STARTING BOXES FOR ROLL MOTORS

pulley and a belt tightener, though not essential, is frequently installed to secure proper belt tension, particularly when the angle of the belt approaches the vertical. The flywheel effect of the lower bandmill wheel assists in reducing the peak loads on the motor during the heavy cuts.

The live rolls, the first link in the interior transportation chain after the log has passed the head saw, form an exceedingly important factor. If they are shut down, the operation of the entire mill is affected. Live rolls, which require frequent reversal, are operated by wound-rotor motors and are controlled from a small cage or station overlooking the rolls. In some cases where the rolls are not reversed frequently or do not start under severe conditions, squirrel-cage motors may be applied. Where it is desired, several sections of the rolls may be operated from the same motor-driven shaft, through friction clutches. However, the driving of each section with its individual motor is generally more advisable. The power requirements for the rolls vary so much that it is difficult to give definite capacities, but the sizes generally required are from 3- to 15-hp., depending on the size, number and speed of the rolls. In order to secure the low speeds desired, back-geared motors with rolled-chains and sprockets are generally used, driving direct from the back-gear shaft to the live-roll shaft. A particular advantage of the electric operation of the rolls is the ability to reverse quickly and "spot" accurately a piece of timber over a jump saw or section of a transfer chain.

Transfer chains are frequently remote-controlled by means of contactor panels, and squirrel-cage motors with high-resistance end-ring rotors are proving very satisfactory as the motive power. One particular advantage in using remote-control operation of these motors is that the transfer chains can be started and stopped with ease from two or more widely separated points without any interference from other operators. For such service there has been developed a sturdy type of push-button which is so connected, depending on the function

of the transfer chain, that the chain is in operation only during the period when the push-button is depressed. On the other hand, should continuous operation be desired, the chain is stopped only when the push-button is depressed.

The valves on the steam or air cylinders operating the bumpers and jump rolls, and for raising and lowering the transfer skids, may all be actuated by electromagnets controlled from push-button switches located conveniently to the operator in the same manner as those described for the transfer chains. This system permits two or more operators, even though separated from each other, to have control of the bumpers and rolls.

Jump or swing-up saws are installed at points in the system of live rolls for trimming timbers to specified lengths. In the case of a jump saw the motor is frequently mounted on the saw frame, while the motor driving a swing-up saw is mounted on a stationary foundation, and the belt tension is usually supplied by a swinging belt tightener. The service required of these motors, which are of the squirrel-cage type, is very intermittent and the capacity varies from 7½ to 25 hp., depending on the service.

The live rolls back of the bandsaw carry the slabs to a point in front of the slasher, Fig. 3, where, at the will of the operator, they are transferred off the live rolls by means of trip skids. These skids are raised by a cylinder the valve of which is operated by an electromagnet whose control button is within convenient reach of the operator. Early methods of slasher drive consisted in belting the slasher arbors from an overhead countershaft which was either direct-connected to the motor through a flexible coupling or belted. More modern installations, however, have the arbors in one continuous length for any number of saws, and to which

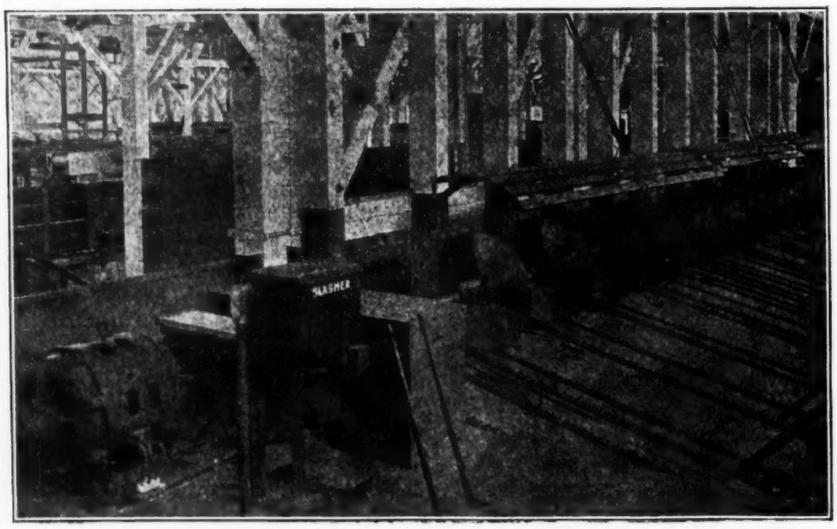


FIG. 3. MOTOR DIRECTLY CONNECTED TO SLASHER IN FOREGROUND

a squirrel-cage motor is directly connected through a flexible coupling. The capacity of the motor required varies from 35- to 75-hp., depending on the kind of lumber cut.

The slasher floor chains in some cases are driven through friction clutches belted from the slasher arbors. More recent and satisfactory drives, however, because of the elimination of the friction and greater flexibility of control, consist in driving the chains by means of a high-resistance end-ring squirrel-cage motor with remote control of the off-and-on type. With this type of drive and control any large load of slabs and edgings that has accumulated on the floor chains can be fed gradually to the slasher saws without danger of jamming or causing them or the arbors any injury.

Boards coming from the head saw to be edged, Fig. 4, and ripped to the desired width by the edger are carried on rolls to a point directly opposite and are then trans-

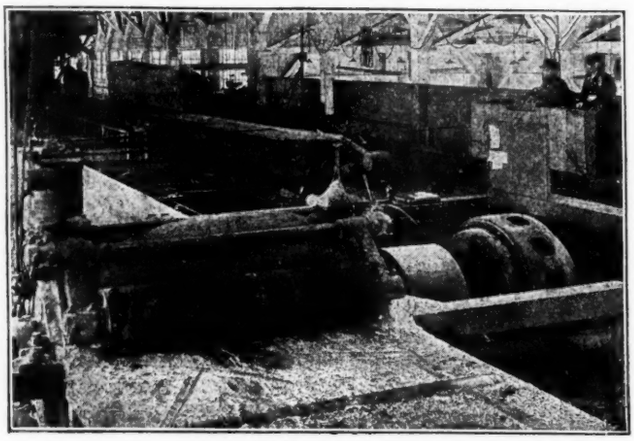


FIG 4. ROLLS ELECTRICALLY CONTROLLED BY OPERATORS IN SMALL BOOTHS—EDGER SHOWN

ferred sideways on the chains which take them to the edger. In some mills this transfer of boards is made automatic by raising a stop at the proper point in the rolls. When the board strikes the stop, it closes the circuit of a control switch causing the trip skids to rise and trip the board off the rolls onto the chains, thence to the edger. The transfer chains are usually driven by high-resistance end-ring squirrel-cage motors with a remote-control button placed within easy reach of the edgerman's foot, so that he may readily bring each piece up to the machine as he desires. The edger drive consists of a squirrel-cage motor of from 35- to 250-hp. capacity, depending on the kind of lumber and the cutting speed, directly connected through flexible couplings to the edger arbor. Except in the case of extremely large sizes it is entirely satisfactory to place the rotor of the motor on the edger arbor in the position usually occupied by the drive pulley in belt-driven edgers.

After passing through the edger the boards and edgings are carried along over the slasher floor chains on which the edgings from the edger are thrown, the boards continuing along these rolls and being delivered edgewise onto the trimmer chains. These are driven by a high-resistance squirrel-cage motor with remote control, the button of which is located so that the operator placing lumber on the trimmer can reach it with his foot and start or stop them as desired. The trimmer is driven by a squirrel-cage motor of from 25- to 75-hp. capacity directly connected through a

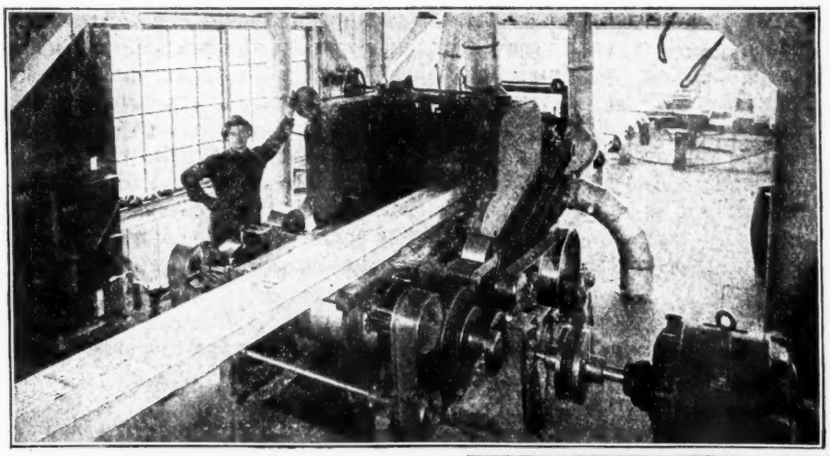


FIG. 5. MOTOR DIRECTLY CONNECTED TO TIMBER SIZER

flexible coupling to the trimmer counter-shaft from which the saw arbors are belted. Feed chains for the trimmer are driven by high-resistance end-ring squirrel-cage motors. The remote-control push button is located in the trimmerman's cage where he can reach it with his foot, affording him easy and accurate control and leaving both hands free for pulling the saws.

The gang saw, which consists of a number of straight saws having a vertical reciprocating and oscillating motion, splits a cant into several boards of the desired thickness. The power requirements vary greatly, depending on the size, kind of lumber and speed of cutting desired. Motors ranging in size from 75 to 250 hp. are required. As the gang is equipped with a flywheel and the saws together with the framework form a considerable mass, the starting duty is rather severe, and a wound-rotor belted motor with an idler pulley to supply belt tension is the proper application.

Although the actual power requirements for the sorting table are not very great, the starting duty is at times unusually heavy, owing to the fact that the table frequently becomes congested with lumber piled up on it, which must be moved, a wound-rotor motor of from 5- to 10-hp. capacity being desired.

It is frequently necessary to resaw lumber to the proper thickness. For this purpose it is taken to the resaw, which is similar in its power requirements to the bandsaw runs. As in the case of the bandsaw, however, when once started the saw acts as a flywheel and assists in pulling through the heavy cuts, a wound-rotor motor is considered the most desirable application, although there are a number of high-resistance end-ring squirrel-cage motors operating resaws very

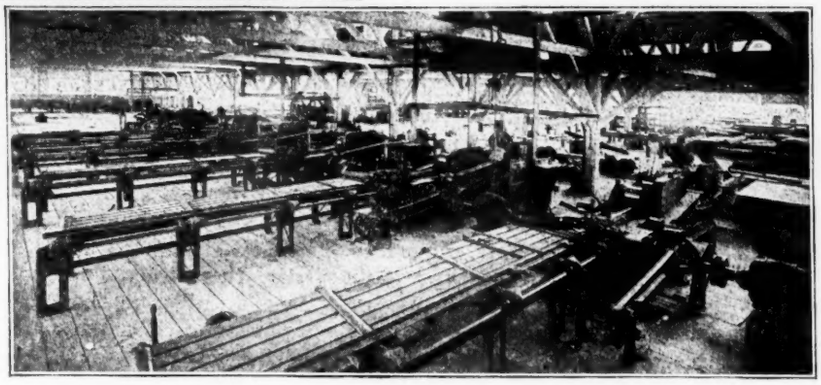


FIG. 6. FIVE FAST-FEED PLANERS DIRECTLY DRIVEN BY INDIVIDUAL MOTORS

SIZES AND TYPES OF MOTORS AND METHODS OF DRIVE FOR LUMBER-MILL APPLICATIONS

	Type	Horse-power	Speed R.P.M.	Method of Drive	Comments
Log haul	S.C. or W.R.	25-50	900	Belted or geared	
Log lift	W.R.	35-50	900	Geared to drum	Solenoid brake generally supplied
Carriage set works	S.C.	5-10	900	Geared, belted or chain-driven	
Headsaw	W.R.	100-300	600	Belted	
Rock saw	S.C.	10-15	1200	Belted	
Live rolls and transfer chains	S.C. or W.R.	3-15	600-900	Back-geared and chain	
Jump or swing-up saws	S.C.	7½-25	600-1200	Belted	
Slasher	S.C.	35-75	900-1200	Direct-connected	
Edger	S.C.	35-250	1200-1800	Direct-connected	
Trimmer	S.C.	25-75	900	Direct connected	Flexible coupling to shaft from which saw arbors are belted
Gangsaw	W.R.	75-250	720	Belted	
Sorting table	S.C.	5-10	900-1200	Direct-connected	High-resistance end-ring motor and friction device generally used.
Resaw	S.C. or W.R.	75	900	Direct-connected or belted	
Stacker	S.C. or W.R.	5-7½	1200	Belted.	
Timber sizer	S.C.	50-75	900	Direct-connected	
Hogs	S.C.	15-100	1200	Direct connected or belted	
Rolls, various kinds	S.C. or W.R.	3-10	900-1200	Chain-driven or geared	
Saw grinders, stretcher, re-toother and scarfing machines	S.C.	2-5	1200	Belted	
Exhaust fans	W.R.	20-150	600-1200	Direct-connected or belted	
Conveyers	S.C. or W.R.	10-25	900-1200	Geared	
LATH MACHINES					
Lath bolter	S.C.	40-50	1800	Direct-connected	
Lath mill	S.C.	25-40	3600	Direct-connected	
Lath trimmer	S.C.	5-10	1200	Direct-connected	
SHINGLE MILLS					
Main saw	S.C.	20	1800	Direct connected	
Trimmer saw	S.C.	3	1800	Direct-connected	
LOGGING					
Donkey-hoist	W.R.	150-200	600	Geared	

Note:—W.R. denotes wound rotor, and S.C. squirrel cage.

satisfactorily. The capacity required for a 7-ft. resaw is 75 hp. The feed rolls are driven by a wound-rotor motor varying from 3 to 5 hp. in capacity. From the sorting table the lumber is handled by various companies in different ways. Generally, it is taken by transfer cars or telphers to stackers, thence to the dry kiln or the lumber yard. In some cases the stacker, which is driven by a 5- or 7½-hp. squirrel-cage motor, stacks the lumber and it is transferred to the dry kiln on iron framework cars and unstacked after drying by an automatic unstacker driven by a motor of 3-hp. capacity. From here the lumber is moved by some method of transportation to the planing mill, lumber shed or railroad cars. as desired.

In some sections it is the practice to have a timber sizer located in the lumber mill, where large timbers can be planed before shipment. The size of the motor, which is usually of the squirrel-cage type and directly connected, varies according to the size of stock, rate of feed, number of sides to be surfaced and the speed, the usual capacities ranging from 50 to 75 horsepower.

Refrigeration Study Course VI—The Brine System

By H. J. MACINTIRE
Professor of Mechanical Engineering, University of Idaho

With the so-called direct expansion system, where ammonia is allowed to boil in the cold-storage rooms there is danger at all times. The pipe lines may become corroded, or split due to imperfect welding, or fittings may be broken by accident. The result is that some or all of the ammonia in that part of the system may be emptied into the room. We have had accidents to liquid receivers where the anhydrous ammonia ran in streams into the street.

Besides the danger to life and commodities, there is also the matter of the initial charge of ammonia. In a large system of long supply and return pipes, or extensive refrigerating piping, the amount of the initial charge has to be very heavy, which requires constant care and repair to maintain the piping tight at all times. The result is that, under certain particular conditions, the so-called brine system is best for the refrigerating piping.

The Brine System of Indirect Refrigeration

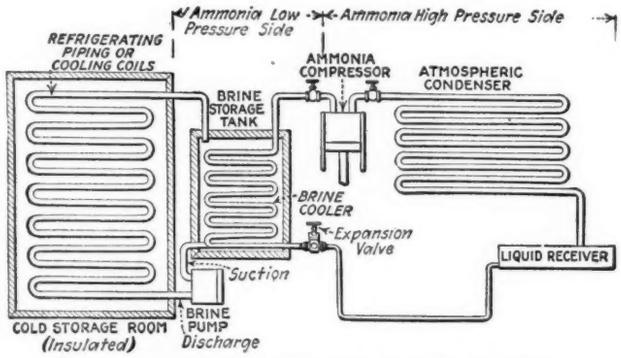
In the brine system of indirect refrigeration, the high-pressure side is the same as in the direct-expansion system. The low-pressure side consists of a brine cooler, usually of the shell and tube type similar in construction to a steam condenser. The brine is a non-freezing solution of sodium or calcium chloride of such density as will not freeze at the temperature carried in the cooling system. On account of the lower freezing temperature of calcium brine, it will be found in most service where zero F. degree brine is required.

The brine sysem, then, is really an additional unit in the system, where the brine is kept cool by boiling ammonia and the cold-storage rooms or other refrigerating applications are kept cold by the brine. The ammonia system is self-contained, and the ammonia piping may be kept constrained to a single room. The brine, however, must be kept circulating constantly by means of a centrifugal or reciprocating pump, and all exposed piping must be well insulated. The brine line need only be full-weight steel pipe with ordinary fittings, valves and cocks. The system is laid out in many ways like an ordinary hot-water heating system.

Advantages of the Brine System

The great advantage of the brine system, other than those already noted, is in the ability to store up energy. With the direct-expansion system the compressor must be operating constantly during the live-load period. If this is not done, the pipes will soon lose their frost and the room temperature, or the commodities being cooled, will begin to increase in temperature. With the brine system, this is not true, as "cold" may be accumulated in the brine and this may be circulated while the compressor is shut down. In fact, the example may be carried considerably farther in certain kinds of service that are intermittent, as ice-cream making, milk and drinking-water cooling, the chill room of the packing house, or where refrigeration is required suddenly.

In cases of periodic load the brine-storage tank becomes an advantage. In such a case refrigeration may be stored by cooling a large volume of brine through as large a temperature range as is practical.



DIAGRAMMATIC LAYOUT OF BRINE SYSTEM

The compressor may be operated 24 hours of the day, thereby utilizing a much smaller machine than would be required if no brine was used and the compressor capacity had to be capable of the maximum rate of cooling. It will be seen that by means of brine the peak load is distributed during the whole day of 24 hours, whereas the load may last only three hours. Energy is accumulated in the same sense as in the case of an engine flywheel.

Disadvantages of the Brine System

There are, however, certain disadvantages in the use of brine. The first cost and the operating cost are usually greater. The brine pump has to be operated by independent power. In addition, and more serious than anything else, are the losses incident to the use of brine. It will be remembered that the brine is first cooled in a brine cooler, and the ammonia may be required to boil at 16 deg. F. to carry brine at an average temperature of 26 deg. F. Likewise, the air to be cooled in the cold-storage room could be kept at a corresponding temperature of 36 deg. F., thus allowing 10 deg. difference of temperature in each case. The

capacity of the compressor would be determined by the temperature of the boiling ammonia, which would have been 26 deg. F. in the case of direct expansion. In the brine system, therefore, it is necessary to boil the ammonia at considerably lower pressure than with the direct expansion, thereby costing more per ton of refrigeration for the power input, and reducing the capacity of the compressor.

The brine required for a given condition may be calculated easily. The "heat capacity" of a certain volume of brine depends on the product of the density (specific gravity) and its specific heat (heat units required to raise one pound one degree F.). For instance, the cooling effect of 100 gal.. of brine in raising 4 deg. F. would be

$$\underset{\text{Deg. Range}}{4} \times \underset{\text{No. Gal.}}{100} \times \underset{\text{Wt. 1 Gal.}}{8\tfrac{1}{3}} \times \underset{\text{Sp. Gr. Brine}}{1.2} \times \underset{\text{Sp. Heat Brine}}{0.7} = 2{,}700 \text{ B.t.u.}$$

assuming 1.2 for the specific gravity and 0.7 for the specific heat of the brine. These values change with each concentration of brine solution.

If it is required to find the amount of brine per minute necessary to provide one ton of refrigeration with a five-degree range of temperature, the calculation becomes

$$200 = \textit{No. gallons} \times 8\tfrac{1}{3} \times 1.2 \times 0.7 \times 4$$

$$\textit{No. gallons per minute} = \frac{200}{8\frac{1}{3} \times 1.2 \times 0.7 \times 4} = \frac{200}{28} = 7.14 \textit{ gallons}$$

Chart for Determining Proportions of Gear Teeth

By J. H. McManus and L. J. Ehlinger

The accompanying chart is based on Lewis' formula for the strength of cast-steel pinions. This formula, as applied to a 15-tooth pinion, is as follows:

$$C.P. = \sqrt[5]{\frac{0.36\ hp.^2}{r.p.m.}}$$

where *C.P.* equals circular pitch of the pinion.

To use the chart, draw a straight line from the horsepower transmitted on the left-hand scale to the revolutions per minute on the right-hand scale and read off the pitch on the central scale. The example shown on the chart is for a 15-tooth pinion transmitting 30 hp. at 200 r.p.m., and as shown, the circular pitch would be $1\frac{1}{8}$ in., or the diametral pitch about $2\frac{3}{4}$ in. The face of the teeth, which should be three times the circular pitch, would then be three times $1\frac{1}{8}$ or $3\frac{3}{8}$ inches.

If the chart is to be used for pinions having more or less than 15 teeth, multiply the actual horsepower by $0.027\ N + 0.6$, where N is the number of teeth in the pinion. Then use this corrected horsepower on the chart and proceed as in the case of a 15-tooth pinion.

As an example of the use of the chart for the design of a complete gear train, assume a 75-hp. motor running 1,000 r.p.m., driving a hoist drum running 10 r.p.m. through two intermediate shafts, the first running 250 and the second 50 r.p.m. Pinions being the weakest part, determine their circular pitch and face and follow through the various reductions to the drum.

Assuming a 15-tooth pinion on the motor with 75-hp. and 1,000 r.p.m., the chart reads $1\frac{1}{8}$ in. circular pitch and three times this for the face gives $3\frac{3}{8}$ in. The driving pinion on the first shaft transmits 75 hp. at 250 r.p.m., and the chart shows this to give $1\frac{1}{2}$ in. circular pitch and therefore $4\frac{1}{2}$ in. face for the teeth. The pinion on the second reduction shaft transmits 75 hp. at 50 r.p.m., which from the chart should be 2 in. circular pitch and therefore 6 in. face. Thus the circular pitch and face are determined for each gear of the complete train.

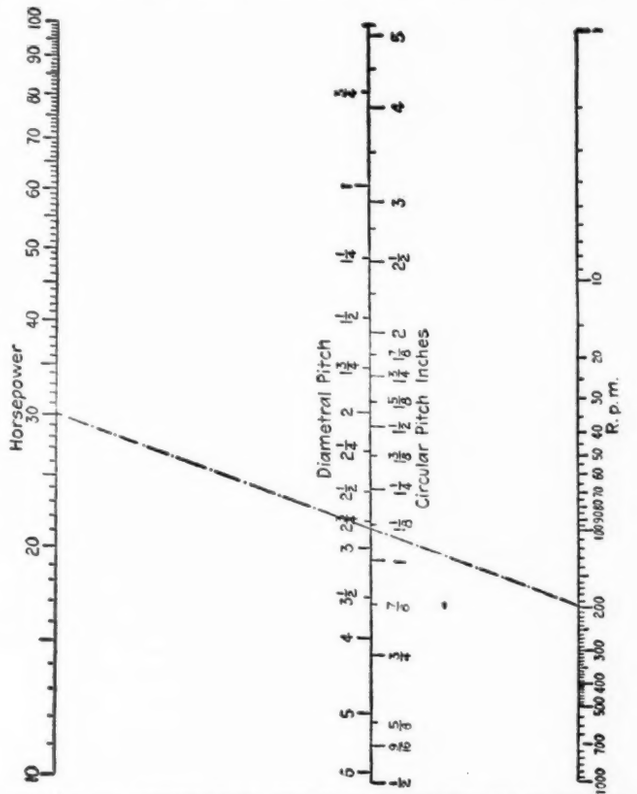


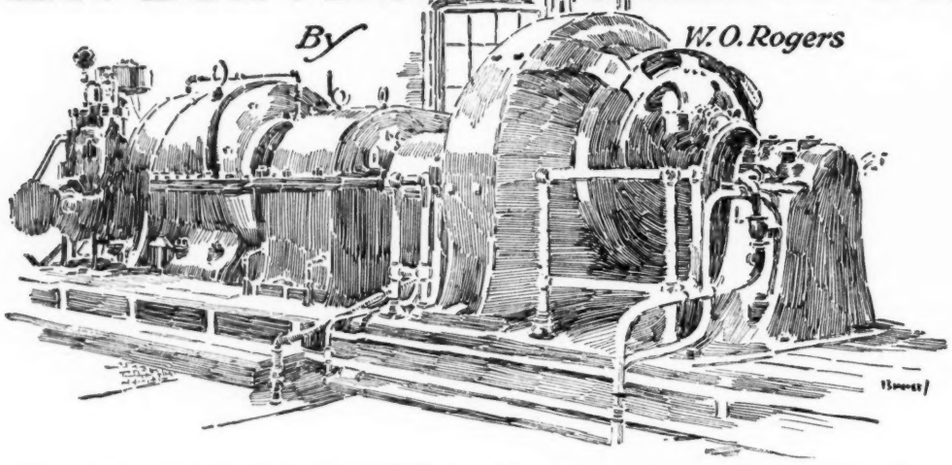
CHART TO DETERMINE PITCH OF 15-TOOTH CAST STEEL PINIONS FROM LEWIS' FORMULA

Applications covering an expenditure of approximately $40,000,000 for power purposes in the State of California were filed with the State Water Commission during the month of December, according to a recent statement of the commission. The largest application made during the month was that of Allen Talbot for the Modesto irrigation district, who asks for a permit to appropriate 10,000 cubic feet per second from the Tuolumne river in Tuolumne County. He proposes to impound 120,000 acre-feet of water and to develop 120,000 hp. The cost of the project is placed at $16,000,000. Canals and tunnels $22\frac{3}{4}$ miles long are planned, with a steel and concrete dam 330 feet high and 850 feet long on top. At its base the dam will be 150 feet long. A second dam of concrete 250 feet high is planned, the length to be 800 feet on top and 50 feet at the bottom.

There was a station mechanic who could not understand why a man younger in the service was made foreman instead of him. One day the foreman left an outline of some work for the mechanic to do. In too literally following instructions, the mechanic burnt out some valuable equipment and shut the plant down. Taken to task, he exclaimed: "I didn't make the 'bull,' he did it! *I only did what he told me to.*" Still the mechanic wonders why he was not made foreman.

POWER DRIVES for ROLLING MILLS

By W. O. Rogers



Up-to-date power stations were found in which were installed reciprocating engines of various types, high-pressure and mixed-pressure turbines. The reciprocating engine predominates, but a number of turbines have been added to the original power-plant equipment. Although the mixed-pressure turbine seems to be the logical unit to use with reciprocating engines, but two were found in operation.

AFTER visiting the boiler houses that produce steam for the rolling mills, I next took in some of the engine and turbine rooms. It required several days to inspect and photograph the units. In the plants visited the Corliss type of engine was generally used, directly connected to either alternating- or direct-current generators. Figs. 1 and 2 are views of two power plants. This does not mean that the steam turbine is not used, because in some of the mill power stations, both high-pressure and mixed-pressure turbines have been added to the original equipment. The generating unit produced energy for motor drive, electric lighting, etc. These units are housed generally in a neat brick building and are, in fact, a regular central generating station and not scattered about the plants as many might suppose.

As might be expected, the power-plant units operate condensing, and the reason that more turbines are not found in operation is doubtless due to the fact that the Corliss engines were installed when that type of unit was the best procurable and before the turbine had established itself in the power-plant field.

When it comes to the best type of prime mover for a large-sized power plant, the turbine is the most economical in steam consumption when operating condensing, and in maintenance cost, the size requiring fewer operatives. The plant engines that I saw were compound condensing. Figs. 3 and 4 are examples. These units operate condensing and range around 400 to 500 kw. capacity with a speed of from 75 to 100 r.p.m. and generate direct-current energy.

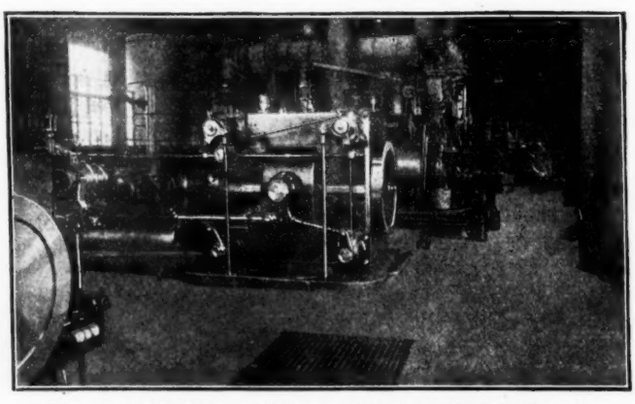


FIG. 1. POWER PLANT AT THE BERGER MFG. CO.

If these medium-speed engines operated non-condensing, the steam consumption would average, with 150 lb. steam pressure, about 19.5 lb. per i.hp. at full load, 21.7 lb. at three-quarter load, 26.8 at one-half load, and 39.5 at one-quarter. Operating condensing with 26-in. vacuum and corresponding cutoff in the high-pressure cylinder, the figures would be 15.4 lb. of steam at full load, 15.7 at three-quarter load, 16.3 at half load, and 22.5 lb. at one-quarter load. This makes a difference in steam consumption per indicated horsepower, in favor of the condensing engine, of about 5.1 lb. of steam at full load, 6.5 at three-quarter load, 10.5 at one-half load, and 17 lb. at one-quarter load.

Although the foregoing figures are approximate, they are based on tests that have been made on similar engines and are given so that a comparison of steam consumption between condensing and non-condensing units may be had. If the engines referred to are in good condition, the steam consumption should be around the figures given. As a general thing, however, the steam consumption will be higher.

Many engineers are of the opinion that a gain in steam economy, due to the use of a condenser, indicates a corresponding gain in heat consumption, but this is not so. For instance, an engine might show an apparent gain due to running condensing of, say, 12.5 per cent, with the feed water returning to the boilers at 120 deg. F. If a suitable feed-water heater were used with a non-condensing engine, the water should be heated to around 210 deg., and a non-condensing engine would therefore be credited with the difference of 90 units per pound of steam used, or 9 per cent in round numbers. The difference between 12.5 and 9 per cent is 3.5

per cent, which represents the net gain in favor of using compound engines. This, however, ignores the power necessary to operate the vacuum, circulating and condensate pumps, and the steam consumed by the condenser pumps might be equal to or greater than 3.5 per cent of the steam generated, so that the net gain would be nothing or even negative. By using superheated steam, a greater economy will be obtained than when using saturated steam, but the first cost, maintenance and the disposition of the exhaust must be considered in determining the final gain. The troubles encountered in using superheated steam have been largely overcome by the use of suitable lubricants.

FIG. 2. POWER PLANT AT THE REPUBLIC IRON AND STEEL CO.

Steam turbines make an ideal power unit. They are generally used to drive alternating-current generators, but I found that the steel mills use them for driving turbo-blowers and pumps, and by means of gearing the turbine is used to drive reciprocating air compressors, rolling mills and other types of slow-speed machinery. A turbine has the advantage of first low cost, low maintenance cost, small floor space required and low cost of attendance.

Turbines are grouped under the classification of impulse single-pressure stage having both single- and multi-velocity stage; reaction multi-velocity stage, multi-pressure stage; and combined impulse and reaction with multi-velocity stage, multi-pressure stage.

In the impulse type of turbine steam is expanded and the heat given up by the pressure dropped imparts velocity to the jet itself. The jet impinges against the vanes of the rotating wheel and gives up its kinetic energy to the wheel. Turbines used in driving centrifugal pumps, blowers, etc., are generally of this type.

Reaction turbines convert the potential to kinetic energy in the moving blades as well as in the fixed blades, and but a small portion of the heat energy imparts velocity in the first set of fixed blades, and the jet from the nozzle impinges against the first set of moving blades and imparts its kinetic energy to the rotor by impulse. The blades are so proportioned that partial expansion takes place in them, and the resulting increase in velocity exerts a reaction which forces the rotor in its revolutionary motion. In the combined impulse and reaction type of turbine, the high-pressure elements are of the impulse type and the low-pressure elements of the reaction type. Figs. 5 and 6 are good examples of the modern turbine unit found in operation in steel mills. These are at the main plant of the Youngstown Sheet and Tube Co. They are of 3,000- and 3,500-kw. capacity respectively. Two turbines, shown in Fig. 7, were added to the power plant of the Republic Iron and Steel Co. and are on a mezzanine floor at one end of the engine room. This floor also extends around one side of the room, and here the switchboard is located. These units are of 2,500- and 3,500-kw. capacity, generating 6,600-volt direct current. Opposite these turbines on the mezzanine floor, is a 750-kw. mixed-pressure turbine, also generating 6,600, and is shown in Fig. 8. This unit uses exhaust steam from a 24- and 48 x 47-in. cross-compound Corliss engine running at 100 r.p.m. and directly connected to a 1,000-kw. 250-volt d.c. generator. See Fig. 9.

The energy developed by a mixed-pressure turbine is, as someone has put it, like getting something for nothing. Although this is not exactly the case, a considerable gain in economy and capacity is obtained by using the exhaust steam from a non-condensing reciprocating engine. The turbine is connected between the exhaust of the low-pressure cylinder of the engine and the condenser. With the engine developing 1,000 kw., by using the exhaust steam in the mixed-pressure turbine an additional 750 kw. is obtained with the steam that has already developed 1,000 kw. of energy, instead of exhausting the steam to the atmosphere, where the heat is wasted. An engine of 1,000-kw. capacity running at normal load and a turbine generating 750 kw. means that the total capacity has been increased 75 per cent. over the original capacity of the engine alone, and that the saving in steam consumption in making this gain should be about 18 per cent.

A mixed-pressure turbine is in many respects similar in construction to the ordinary high-pressure

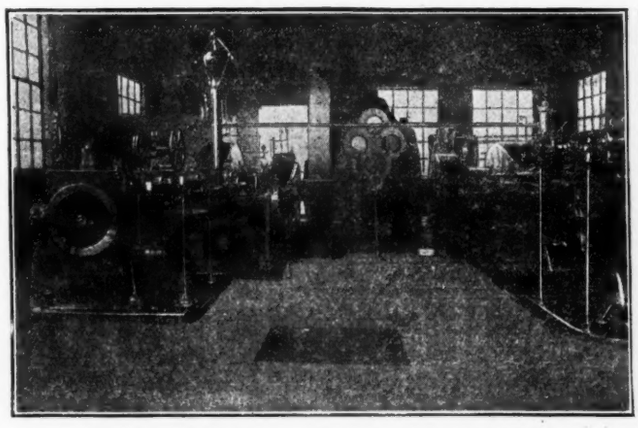


FIG. 3. TYPICAL CROSS-COMPOUND UNIT

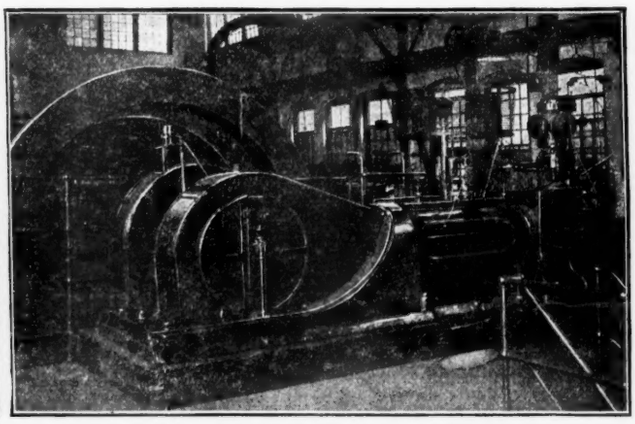


FIG. 4. ANOTHER CROSS-COMPOUND ENGINE

turbine. The main thing in its favor is to utilize the greatest amount of exhaust steam about the plant. Means should be used to remove water and oil from the exhaust steam before it enters the turbine. Water

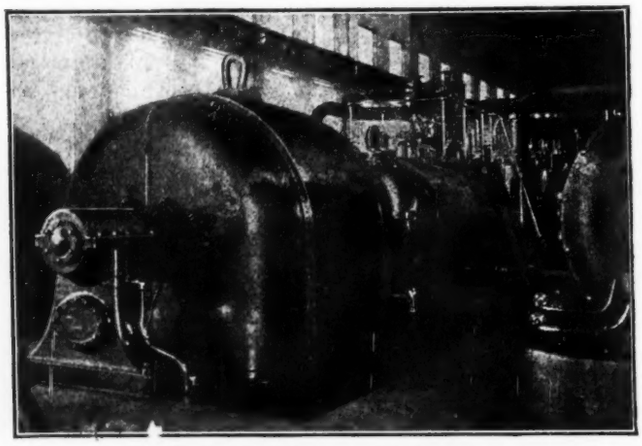


FIG. 5. MODERN TURBINE INSTALLATION AT THE YOUNGSTOWN SHEET AND TUBE CO.'S PLANT

increases the fluid friction in the turbine blading, and this of course reduces the output and increases the steam consumption. Oil itself may not be detrimental to the turbine blading, but it will cause trouble when it combines with sulphates and carbonates that may come over with the steam in case the boiler foams. The gummy substance formed will be deposited on the blades and may clog the steam passages between the blades. Because the mixed-pressure turbine is connected directly to the engine exhaust, its output will vary according to the load on the engine. With a light load, the volume of exhaust steam will be reduced, owing to earlier cutoff of the engine. In cases where the engine and turbine are generating alternating current on the same circuits, no governor is required on the turbine, because it will automatically take its share of the load in proportion to the amount of steam it receives. If it tries to take more than its share, the engine will run faster and cause its governor to make an earlier cutoff, which will reduce the flow of steam to the turbine.

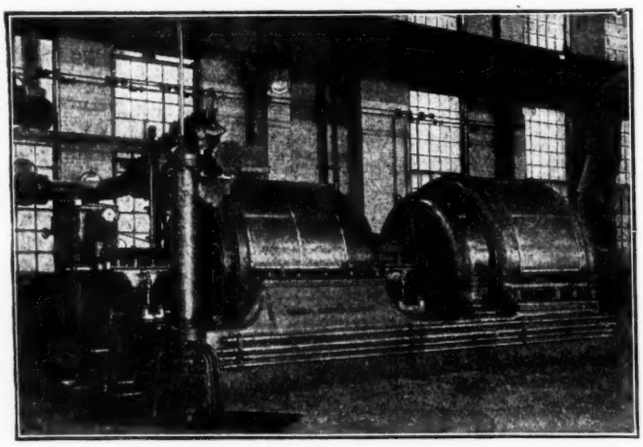


FIG. 6. SIDE VIEW OF A 3,500-KW. TURBINE AT THE YOUNGSTOWN PLANT

If the units are generating direct current and the turbine attempts to take more than its share of the load, the increase in its speed slightly raises the voltage, which sends more current to the generator fields, and this tends to reduce the speed, thus maintaining self-regulation. The greater the amount of steam supplied to the turbine the greater proportion of the load will be taken by it, this being due to the pressure variation in the receiver of the engine.

In the installation shown in Figs. 8 and 9 the engine generator produces direct current and the turbine alternating current. Therefore it is necessary that both the turbine and the engine be controlled by its own governor. In order to prevent waste of steam when the direct-current load is heavy and the alternating-current load is light, it is customary to use a rotary converter or motor-generator set, and thus any difference in load will be taken care of and the load coming on the engine and on the turbine will be proportioned equally. If the direct-current load happens to be light at the time the alternating-current demand is great, the turbine is supplied with high-pressure steam, its admission being cut in or out as the turbine load and the amount of exhaust-steam supply demand. This was the arrangement at the Republic works.

With one exception, all the engines that I saw driving mill rolls in the various plants exhausted steam to the atmosphere. This waste steam could be utilized by a mixed-pressure turbine, as could steam from other intermittently operated units, by the use of a regenerator accumulator, which regulates the flow of steam before it goes to the turbine. The steam, upon entering the regenerator, condenses and is again vaporized during the time when the engine exhaust diminishes or is stopped altogether. If sufficient capacity is provided, the accumulator can be made to provide a practically constant supply of exhaust steam for the turbine.

The accumulator, or regenerator, is a large cylinder partly filled with water. The engine exhaust is delivered to it as a spray through small holes in pipes submerged in the water, thus condensing some of the steam and so giving up heat to the water, bringing the temperature to around 212 deg., which is the temperature of the exhaust steam. When the engine stops, as rolling-mill engines do at intervals, the supply of steam is discontinued and the flow of steam from the regenerator to the turbine will cause the pressure to fall slightly, so that 212 deg. will then be slightly higher than the temperature of boiling water at this low pressure. The water will then evaporate to supply steam to the turbine. When

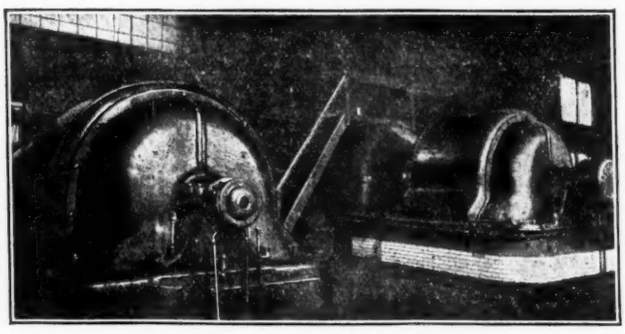


FIG. 7. TURBINES THAT HAVE BEEN ADDED TO THE ORIGINAL EQUIPMENT

the engine starts again, steam is delivered to the accumulator at a temperature slightly above that of the water, which has been lowered because of the cooling effect of the evaporation when supplying the turbines, and

the water will again absorb heat from the steam. Of course, if the engine is shut down for some time, the heat stored in the water in the accumulator will become exhausted and the pressure will fall below that necessary for the operation of the turbine. This is overcome by automatically admitting live steam through a reducing valve. The pressure in the accumulator runs

FIG. 8. MIXED-PRESSURE STEAM TURBINE

about 6 lb. per sq.in., and excess pressure is discharged through a relief valve.

I found an accumulator in use at but one of the mills, and it is probable that the operation of the rolling-mill engines and their distance from the central power stations have a determinate influence in running without the use of such an apparatus and allowing the exhaust to escape to the atmosphere. This installation was at the main plant of the Youngstown Sheet and Tube Co., in which the blooming-mill engine exhausted in passing to heat boiler-feed water and to operate a low-pressure turbine.

As the steam pressure used in mixed-pressure turbines is low, the steam consumption per brake-horse-

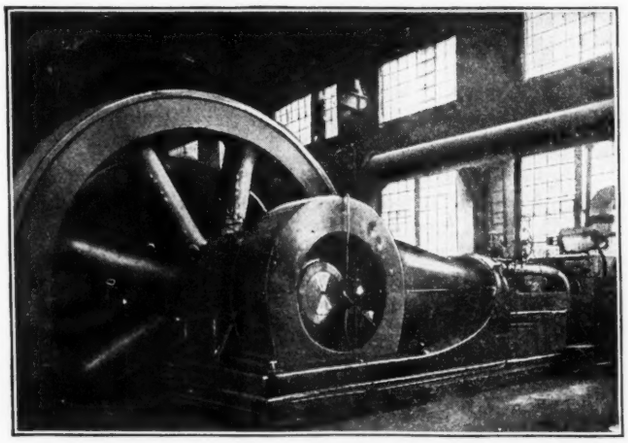


FIG. 9. ENGINE EXHAUSTS TO A MIXED-PRESSURE TURBINE

power will be around 38 lb. with a 28-in. vacuum and a steam pressure of 6 lb. absolute initial pressure.

In an exhaust-steam turbine the steam enters through the top of a turbine casing and is distributed to both ends of the rotor, exhausting to the condenser at the bottom. In a mixed-pressure turbine there is a high- and a low-pressure section. The high-pressure element is of the impulse type and the low-pressure element is of the reaction type. The high-pressure steam enters the turbine opposite the impulse section and low-pressure steam behind the reaction section. The mixed-pressure turbine differs from the low-pressure turbine in that it has a governor which controls the valves that in turn control the live-steam admission to the nozzle that admits steam to the high-pressure section before discharging to the low-pressure section along with low-pressure steam with which it mixes.

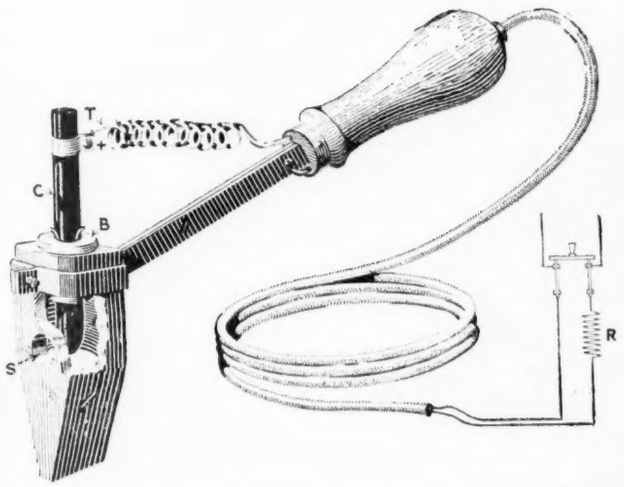
After seeing numerous kinds of power-plant units, many of which were duplicated, attention was turned to an interesting installation of two of the largest poppet-valve uniflow engines in the world, which were used to drive a 9- and a 12-in. merchant mill.

An Electric-Arc Soldering Iron

By B. A. Briggs

Most electric soldering irons are constructed so that they are heated by the current passing through a resistance coil inclosed in a tube attached to the top of the iron.

The illustration shows an electric soldering iron that is heated by an electric arc in the iron itself. A hole is bored in the center of the iron, having a diameter equal to the outside diameter of the tube of a battery bushing, down to where the iron begins to taper. A standard battery porcelain bushing *B* is placed in the hole and a ⅜-in. arc-lamp carbon *C* is placed in the



ASSEMBLY OF ELECTRIC-ARC SOLDERING IRON

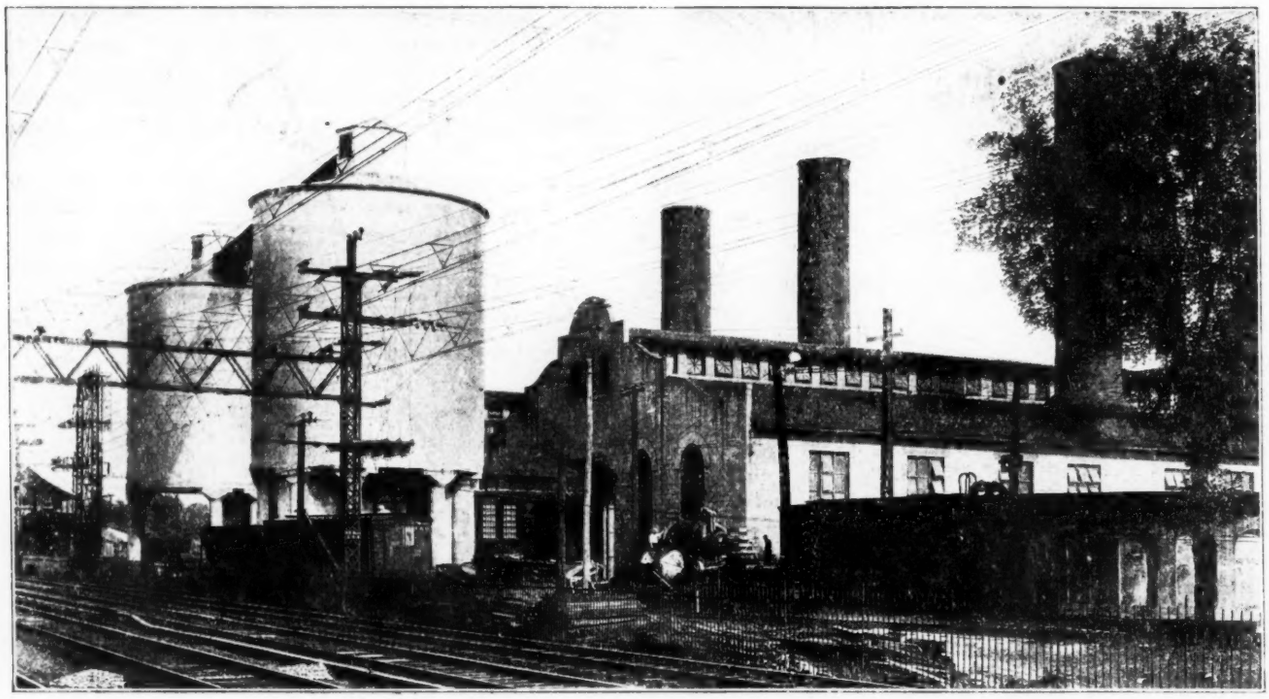
bushing, and allowed to come down in contact with the bottom of the hole, then the carbon is withdrawn about ¼ in. to establish the arc. The iron should be connected to a 110-volt circuit and resistance enough connected in series to keep the current down to between two and three amperes. About 30 ohms will be sufficient. This resistance may be made of about 600 ft. of No. 18 B. & S. iron wire and connected in the circuit, as at *R* in the figure. The soldering iron is connected to the circuit with the positive terminal on the carbon, as shown at *I*.

The carbon is held in place in the bushing by small metal wedges, and adjustment of the carbon is made by tapping it down to give the desired length of arc. A second hole *S* is bored at right angles to the first, so as to allow the arc to be cleaned of the nitrate that forms around it.

Improved Coal-Handling Facilities at Cos Cob*

THE severe winter of 1918 acted as a spur to many power generating companies to enlarge their coal-storage facilities as a means of insuring themselves against any possible failure of the transportation systems. During this memorable winter not one but many an operator was on several occasions within a few hours of exhausting all available coal, and there were even some shutdowns. It was this unprecedented condition which caused the officials of the New York, New Haven & Hartford R.R., to lay plans at once for amplifying the coal-handling facilities of the Cos Cob (Conn.) generating station, which supplies a large portion of the energy for the New York-New Haven electrified division.

Accordingly, Gibbs & Hill, consulting engineers, of New York City, were given the task of working out and installing a suitable plan, and the result includes many interesting features.



TWO CYLINDRICAL CONCRETE COAL BUNKERS, ONE FOR EACH BOILER ROOM

Original Facilities Inadequate

The Cos Cob power station is a plant of 28,000 kw. capacity, having a twenty-four-hour coal-consumption rate of from 350 to 450 tons. It is laid out in a long turbine room with two boiler-room wings extending out from the north side. Normally, all coal is received by tidewater shipments from Perth Amboy. The coal used is mostly run-of-mine Pennsylvania bituminous fuel. With the original coal-handling equipment, the coal has been picked up from the barges with a grab-bucket hoist, dumped into a crusher tower, and carried in cars over an inclined railroad from the crusher to the overhead bunkers in the two boiler rooms. These overhead bunkers furnished a storage capacity in the plant of 150 tons for each boiler room.

What little coal has been received by rail in the past has been dumped into two track hoppers, one at the end of either boiler room. These hoppers have a capacity of about 50 tons each and are equipped with a crusher from which the coal is delivered by bucket conveyor to the overhead bunkers.

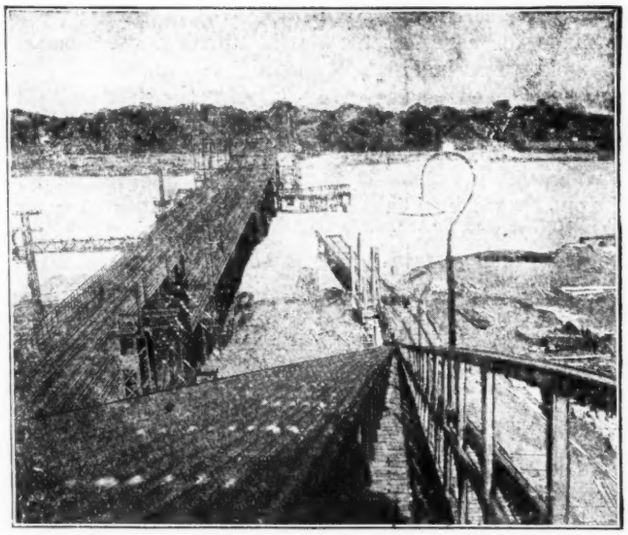
With this original coal-handling arrangement, it is seen that practically the only provision for reserve coal supply was that afforded by barges held alongside the dock in the river. This served the purpose with reasonable safety until the unprecedented conditions of the 1918 winter made it impossible to receive coal by barge for many days at a time. As the supply by rail was likewise uncertain, the need for adequate storage facilities on the ground became obviously imperative.

The plans contemplate an extensive remodeling of the coal-handling and storage facilities for the future, the part of which now completed and herein described will give an addition of 2,000 tons capacity to the power-house storage bunkers. Later, it is proposed to provide a storage and handling plant near the power house, to be used in conjunction with the new bunkers.

Just beyond the end of each boiler room a cylindrical concrete storage bunker has been erected and supported on concrete columns with a clearance of 19 ft. from the boiler-room floor level to the top of the bunker. An extension of the firing aisle in each boiler room was provided to a point directly beneath the bunkers, the overhead trackway for the double weighing lorry system being extended through a doorway made in the wall of each. Thus the lorries can be run underneath the bunkers and filled by gravity through the bottom gates, then return down the firing aisle to deliver the coal in known quantity to the several stokers.

The standard-gage side track which formerly served

*Electric Railway Journal.



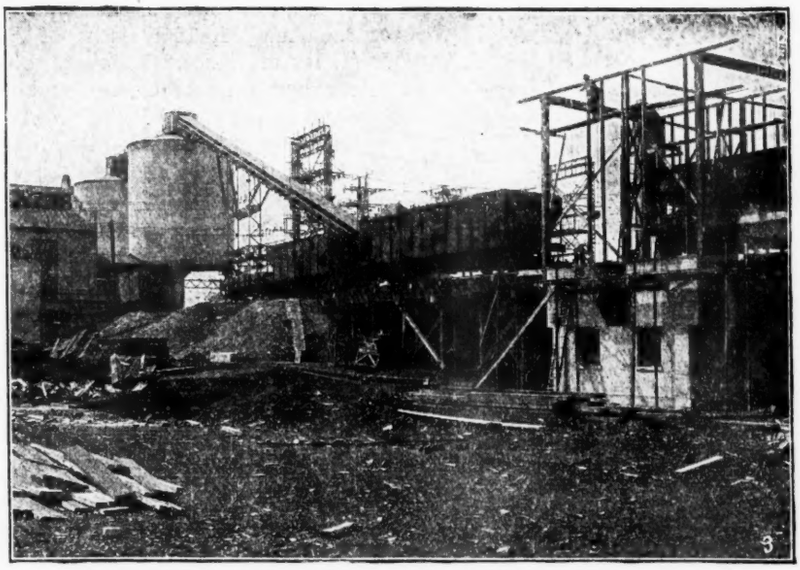
LOOKING DOWN INCLINED CONVEYOR STRUCTURE

the two auxiliary track hoppers was extended out onto a wooden trestle and over a new track hopper which discharges into a crusher of 150 tons per hour capacity. Coal dumped into this hopper passes through the crusher and is discharged onto a 24-in. belt conveyor which is driven at the rate of 400 ft. per min. by a 50-hp. squirrel-cage motor. This belt rises at an angle of 16 deg. with the horizontal, and delivers the coal at an elevation of 97 ft. into the cupola at the top of the first concrete bunker. In this first cupola a sort of butterfly valve is provided which, when set in one position, discharges the coal from the main conveyor into the first bunker, and when thrown to the other position, discharges onto another conveyor running between this first bunker and the cupola of the second bunker. This conveyor between bunkers is also a 24-in. belt, which is driven by a 10-hp. squirrel-cage motor mounted with its starting box in the cupola of the second bunker. This belt between bunkers is 112 ft. long between centers; the main belt from the crusher to the first bunker is 330 ft. long between centers.

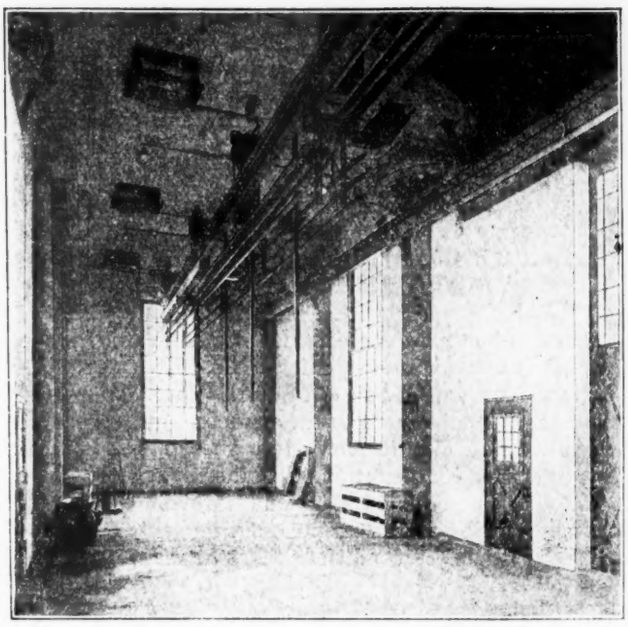
The "silo" type concrete cylindrical tanks measure inside 40 ft. in diameter and 46 ft. high. They are supported on concrete columns, of which the outer ones are 2 ft. 6 in. in diameter and the inner ones 3 ft. The cupolas in which the conveyors discharge into hoppers are octagonal in shape and 12 ft. 6 in. in diameter with walls 8 ft. high and a peak 11 ft. high. The walls of the cupolas and those of the tanks are 11 in. thick and are reinforced by steel hoops and vertical steel rods, the latter serving as vertical ties and also as supports for jacking up the forms during construction. The bottoms of the bunkers are of mushroom slab construction and are hoppered in all directions from the openings in the bottom.

The use of concrete rather than steel for these bunkers was determined partly because of the extreme difficulty of getting steel during the war, when they were built, and partly because the concrete structure involved a less cost as compared with steel at the war prices.

The completion of the conveyor and concrete bunker system adds 2,000 tons of storage capacity to the plant. This alone is sufficient to keep the plant operating, in case of failure of the coal supply, for about seven days. At the present time coal can be supplied to this bunker system only as received by rail, but with the completion of the entire layout the principal path of the coal will be through this conveyor and concrete bunker system. The inclined railway at the opposite end of the plant, which is now handling the coal from the barges to the overhead bunkers, will presumably be done away with. In case of failure of the conveyor system, the contents of the two bunkers can be drawn upon until exhausted, and there still remain the two track hoppers at the end of each boiler room, with the crusher and bucket conveyor system to the overhead bunkers, to fall back upon, coal being supplied by rail.



CONCRETE BUNKER, INCLINED BELT CONVEYOR, TRESTLE AND CRUSHER PLANT



THE BOTTOM OF ONE OF THE CONCRETE BUNKERS

Coal Shortage in Germany

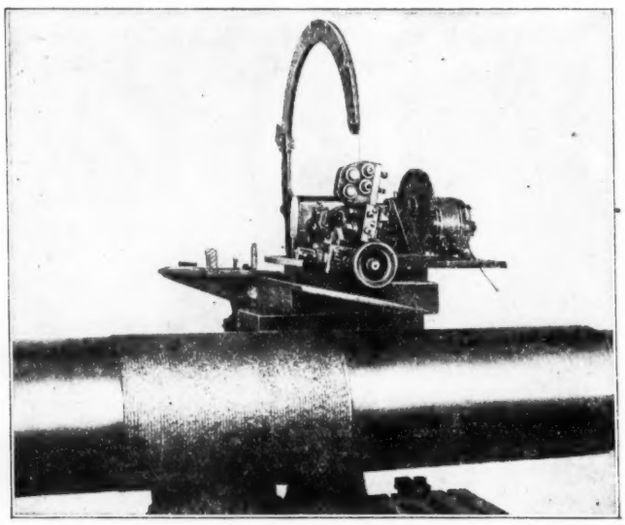
Coal shortage in Germany is becoming more critical each year according to figures taken from a recent issue of *Commerce Reports*.

The peacetime coal production was estimated at 200,000,000 tons. During the past few years coal production has decreased 50 per cent, which cuts the figures to 100,000,000 tons. The coal supply available for industrial and trade purposes is only 26,000,000 tons, whereas the amount required to carry on industrial activity adequately is estimated at 85,000,000 tons.

Excessively low and high water on the River Rhine, which retarded navigation, and railway strikes in Elberfeld and Essen have so hindered deliveries that the coal supply has diminished alarmingly. A railway strike in Upper Silesia and inadequate transportation facilities have reduced the supply to such an extent that deliveries are made only to the most essential industries. Bohemia and Upper Bavaria are also experiencing transportation difficulties, and fuel deliveries have been cut by half.

Automatic Arc Welding Machine

Automatic arc welding is now accomplished by a device known as the automatic arc welder, shown in the figure, which is designed to take the place of the hand-controlled electrode. A pair of feed rolls driven



BUILDING UP SHAFT WITH AUTOMATIC ARC-WELDER

by a small direct-current motor draw in and deliver to the arc a steady supply of wire and automatically maintain the best working distance. The whole is controlled from a small panel. The welding head is held by a suitable support with a certain amount of hand-regulated adjustment and consists of a steel body carrying feed rolls and straightening rolls, which are both adjustable for various sizes of wire.

The control panel carries an ammeter and voltmeter for the welding circuit, as well as rheostats, a control relay and the contactors and switches for the feed motor. It is possible to start and stop the equipment from the work by a pendant push-button switch, but adjustment of the feed conditions must be made from the panel.

The whole apparatus is mounted on a base that can be bolted to any form of support. Thus a great variety of working conditions can be met, but provision must be made for carrying the arc at uniform speed along the weld. For instance, for straight seams a lathe or planer bed may be used, and for circular ones a lathe or boring mill. However, the local conditions will dictate the method to be followed.

The device is especially valuable where a large amount of routine welding is to be done, since it is capable of from two to six times the speed possible to skilled operators and gives a uniform weld of improved quality. It is adaptable to welding seams of tanks and plates, rebuilding worn or inaccurately turned shafts, as shown in the figure, rebuilding worn treads and flanges of wheels, and many other kinds of work. This equipment has been developed and will soon be placed on the market by the General Electric Company.

Resharpening Files

Processes for resharpening files by "biting" with acids is an old trick of frugal mechanics. On page 315 of the Aug. 31, 1915, issue of *Power*, Department of Inquiries of General Interest, the question of "E. P.," asking how files are cleaned and sharpened by chemical treatment is answered as follows:

After removing loose dirt with a stiff brush, the files are cleaned of grease by boiling them about forty-five minutes in a solution consisting of one-fourth pound of salaratus to a quart of water. The files are then to be thoroughly washed in clean water and dried and then placed on end, completely submerged in a solution consisting of one-fourth pound of sulphuric acid to a quart of water. After remaining in the acid solution for about twelve hours, the files should be thoroughly washed in clean water, quickly dried and then given a light coating of kerosene or other thin oil to prevent rusting.

French Patent No. 483,676 describes a more elaborate method for treating worn files, as follows:

The file to be treated must, first of all, be cleaned as well as possible, and be rid of all greasy matter, etc.

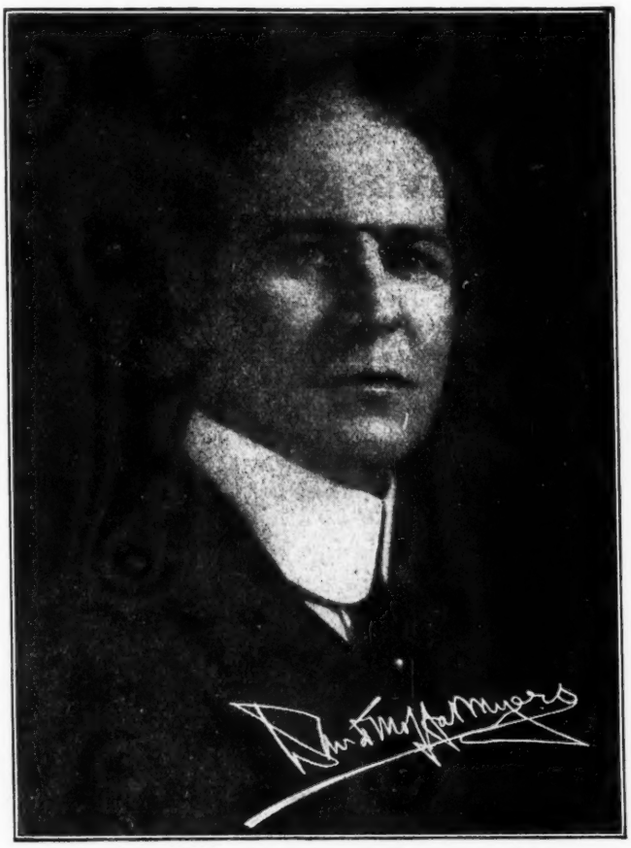
The file is then immersed in a solution of sulphuric acid diluted with four times its quantity of water, in which it should remain for about ten hours. It must then be rinsed in clean running water and carefully dried. After this is done, the file is placed in a glass or enameled metal trough and covered with water into which sulphuric acid is poured until the water reaches 15 deg. C. (59 deg. F.).

After immersion for a few seconds (10 to 15), according to the thickness of the file, the latter is thrown into a bath of cold water to enhance the quenching effect and wash it at the same time.

The third operation consists in placing the file in a small trough containing a piece of lead, and on top of this is poured an aqueous solution of nitric acid and common salt in variable quantities, according to the thickness and the quality of the cuts, and this operation will make the file fit for use again. In this solution the file must remain for 10 to 30 seconds, when it must be rinsed again in very cold water and thoroughly dried. To finish the "cuts," the file is then treated with a solution of oxalic acid for 5 to 20 seconds, according to the thickness of the file. After the file is rinsed again and dried, it must be treated with a solution of sulphate of iron and then with milk of lime, so as to give it a new appearance, and prevent it rusting. Finally, after a further rinsing and thorough drying, the file will be restored to its original condition.

Calculations recently made by an expert, Prof. A. Juselius, show that the amount of water power available for Finland's industries has been greatly exaggerated. He estimates that at mean water level it may amount to 3,000,000 hp. but of this only a small part can be utilized.

A Captain of Coal Conservation



Our obligation to conserve coal—that is, to use coal efficiently—did not stop with the end of the war.

It is not democratic for one plant owner to waste coal recklessly while his neighbor practices scientific means for its efficient utilization. Without coal modern industry could not proceed; the necessities and comforts of civilized life could not exist. Coal as a natural resource presents a problem which concerns the people and therefore the Government which represents them.

It is the privilege and duty of engineers to educate the people as to the facts, so that they will compel Congress to enact appropriate legislation for the prevention of this tremendous and unreclaimable waste of the most valuable of all our national resources.
—DAVID MOFFAT MYERS.

IN DECEMBER, 1917, a paper was presented before the American Society of Mechanical Engineers entitled "Preventable Waste of Coal in the United States," which included a well thought out program for checking this waste. This paper was particularly timely, coming as it did when the Nation was facing the gravest crisis in its history, and so comprehensive was the plan that when it was brought to the attention of the National Fuel Administration, the author was invited to enter that Organization, as Advisory Engineer, to put his theories into practice. David Moffat Myers was the author of this new conservation plan.

The success of the practical application of his theories is indicated by the official report of his work. An annual saving of 25,000,000 tons of coal was effected in the last six months of 1918 through the medium of his original methods. Of the total amount saved 18,000,000 tons was credited to industrial plants of the country and 7,000,000 tons on the railroads. The program included a comprehensive set of recommendations as to methods of fuel economy, which were sent throughout the country to the various power plants using fuel. It further included a system of classification and rating of power plants based on the thoroughness with which the various individual plants were found to be carrying out the standard recommendations. The distribution of fuel was then based on the ratings obtained under this scheme. For the administration of this work a fuel engineering section in the conservation department of the United States Fuel Administration was formed, and Mr. Myers was appointed chief of the section. This involved the organization of fifteen hundred volunteer engineer inspectors in the various states in addition to numerous committee members and other workers.

Mr. Myers received the degree of M. E. from Columbia University in 1901, after preparatory work in both public and private schools; and for five years following his graduation was employed by the United States Leather Company. While with this company he had charge of testing, investigating, and reporting on the fuel and steam conditions of about one hundred plants in different parts of the country. Later his work included the remodeling of old plants and the designing of new ones, for the production of steam and fuel economy. This involved a large amount of engineering research work on waste fuels and on original designs for furnaces to burn them. The waste products of the leather industry are usually very difficult to burn efficiently, as they contain very high percentages of moisture. During this period Mr. Myers designed furnaces that successfully burned waste spent chestnut chips which contained 65 per cent of moisture, and which had resisted all previous attempts to burn without a mixture of coal or some other auxiliary fuel. Since then, he has done a large amount of original furnace designing for various waste fuels, and now has special furnaces working in different parts of this country, in Canada, and in Cuba.

In 1906 Mr. Myers severed his connection with the Leather Company and opened his own office as consulting engineer, specializing on economy of steam and fuel in industrial plants. He numbers among his clients some of the most important industrial corporations, not only throughout the United States, but also in Canada and in Cuba. One of his notable achievements in the power plant field was making feasible a $500,000 annual increase in production in one mill of the Cuba Cane Sugar Corporation, and this enormous economy was obtainable with comparatively small changes in the equipment of the plant. The Midvale Steel Company, through Mr. Myers' investigation, was able to realize a yearly saving of $125,000 which was made possible by the expenditure of some $60,000 for additional equipment. The system involved in such problems as handled by Mr. Myers is divided into two main parts. First, a thorough investigation is made into the fuel and steam conditions of the plant and a complete report submitted covering the recommendations for improvement. Following this, complete plans and specifications for the recommended changes and additions or alterations are prepared, based on the data obtained in the preliminary investigation. From these plans and specifications proper proposals are obtained, contracts let, installation supervised, proper management systems installed and the completed plant is turned over to the client.

In 1915 Mr. Myers became associated with John S. Griggs, Jr., formerly senior partner of the consulting firm of Griggs & Holbrook. The present firm is known as Griggs & Myers, Consulting Engineers, at 110 West 40th Street, New York, and is carrying out the work along the same lines as outlined above.

Mr. Myers is the author of two books on power plant management and design: "Preventable Losses in Factory Power Plants," published in 1914, and "The Power Plant," which is Volume II of the Factory Management Course of the Industrial Extension Institute, Inc., New York. He is also the author of various articles and papers for technical magazines and societies. Among these, a contribution entitled the "Heating Value of Exhaust Steam," was presented at an annual meeting of the American Society of Heating and Ventilating Engineers. In this paper Mr. Myers developed a formula which shows the heating value of the exhaust from any kind of steam engine, turbine or pump. He is a member of an advisory body on fuel conservation known as the Committee of Consulting Engineers to the Bureau of Mines, and he is also a consulting engineer in connection with the sub-committee on coal of the American Society of Mechanical Engineers.

He is a member of the Special Committee of Professional Sections of the American Society of Mechanical Engineers representing the Fuels Section, and has recently been named as a member of the Committee of the American Institute of Mining and Metallurgical Engineers, to coöperate with the Coal and Coke Committee for formulating a plan for the Stabilization of the Coal Industry of the United States. He is also a member of the Columbia University Club, the Cosmos Club of Washington, the Bayside Yacht Club, Theta Xi Fraternity and the American Society of Mechanical Engineers.

Mr. Myers was born January 8, 1879, at Owasto, New York, the son of the late Rev. Alfred E. Myers of New York.

Oil as a Fuel for Boilers and Furnaces

BY H. H. FLEMING

THE paper of which this article is an abstract, was presented at the annual meeting of the American Society of Heating and Ventilating Engineers, in New York, January, 1920, and begins with a brief discussion of the present interest in fuel oils and of the nature of such oils. Regarding the availability of the various oils for fuel, the author points out that the heavy fractions of paraffin crudes are too valuable for lubricating purposes to be burned as fuel. However, the ashpaltum crudes that are now so plentiful can be used for little else than fuel oil and road binders, after their small percentage of light oils has been removed. Consequently, refineries running such crudes are compelled to dispose of great quantities of fuel oil in order to assure the gasoline or kerosene from the crudes. These cheap crudes come mostly from Mexico and, until recently, have not been available in very large quantities, owing to well-known conditions not only in Mexico but in ocean transportation. The war situation having cleared up during the past few months, transportation from Mexico is now nearly normal, and millions of barrels of crudes are sent every month to this country.

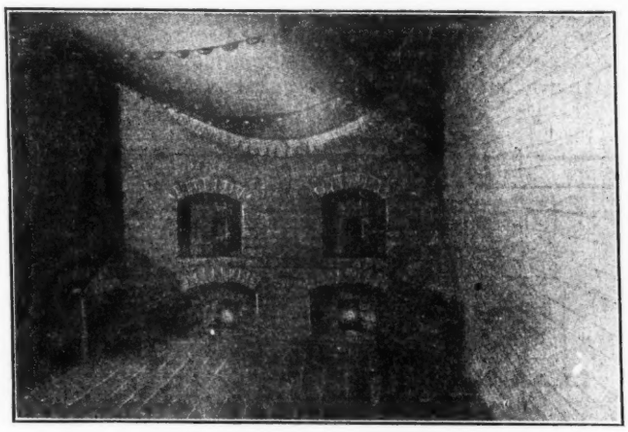
It is expected that the exportations from Mexico for the year 1919 will exceed 80 million barrels, but this is only a small proportion of the estimated potential production. There are single wells in these fields capable of producing over 100,000 bbl. daily. Many wells have been capped or their production greatly cut down, awaiting transportation facilities; that is, pipe lines to the coast and tankers to receive it there, both of which are being constructed as rapidly as possible. Practically the entire Mexican production comes from a strip of land running along the east coast for a little over 100 miles, averaging about 50 miles wide, the principal port of which is Tampico.

The author gives a brief discussion of the advantages of fuel oil over coal, and then takes up the question of equipment required for a fuel-oil installation. This equipment consists essentially of a storage tank, pump, heater and burner with the interconnecting piping. A simple duplex pump is generally used to deliver the oil to the burner, and between the pump and burner the heater is installed which raises the oil to a temperature close to its flash point. The function of the burner is to atomize the oil and spray it into the firebox, where it is burned in suspension. The atomizing is done by steam or air, or mechanically, with hundreds of different types of burners using each method. It seems as though every man who ever burned oil designed an oil burner of his own and patented it. Each designer makes broad claims for his burner, but the author credits Kent with the remark that as long as a burner atomizes the oil,

its design should have no more effect on the boiler efficiency than the design of a coal shovel would have on a coal-fired boiler. The important qualifications of a good oil burner are (1) that it shall atomize the oil to as near a gaseous state as possible, (2) that it shall operate with a minimum consumption of steam or other atomizing mediums and (3) that it shall not clog or suffer from the eroding effect of the steam and oil.

Mechanical burners atomize by forcing the oil under 100 to 300 lb. pressure through slots so arranged that the oil is given a whirling motion. This type of burner is used exclusively in marine work to avoid the loss of water up the stack in the form of atomizing steam.

Burners which atomize by compressed air have been used on board ship, but the compressor equipment is expensive, bulky and costly to maintain. The same objections apply to air-atomizing in shore plants, but it is used in many installations when steam is not available or desirable for the particular work done.



BOILER FURNACE FOR BURNING OIL

Air gives a short, intense flame and is better than steam for some metallurgical work.

For the great majority of stationary plants and locomotives steam is the atomizing medium used, principally because it makes the simplest installation. A good burner, properly operated, will consume 2 to 3 per cent of the total steam generated, or roughly, 3 to 4 lb. of steam per gallon of oil.

The furnace design, not the type of burner, is the important part of the installation. The proper furnace arrangement for burning oil does not differ materially from one designed for burning coal. So the change is generally simple and inexpensive. The most important point to keep in mind in making such a change, is that the flame from the oil burner must not be allowed to impinge directly on any heating surface. The firebox must be large enough to permit combustion to be completed before the flame is cooled by contact with a boiler surface in order to prevent incomplete combustion and the burning out of tubes. A hand-fired coal boiler is often converted to burn oil by merely covering the grate bars with firebricks, laid loosely, leaving a suitable air space directly under and in front of the burner, which is inserted in the fire-door. To secure a larger combustion chamber, the grate may be taken out and the burner placed in the ashpit. The floor of the ashpit should then be built of loosely laid bricks so supported as to admit air underneath them. The hot bricks will then preheat the incoming air. Some prefer to fire from the bridge wall, and every engineer has his own theories as to the value of checkerwork, arches, etc. The accompanying illustration is an interior view taken from the bridge wall of a furnace equipped for oil burning under a horizontal return-tubular boiler.

The stack required for oil is smaller than that used with coal to obtain the same capacity, because less excess air is used, and it is shorter because only sufficient draft to force the gasses through the boiler and breaching is needed, there being, of course, no fire-bed. Forced-draft equipment is discarded except with mechanical burners, where it is possible to use it if exceedingly high ratings are required.

The transportation of fuel oil from the refinery to the consumer is usually by barges, tank cars or tank trucks. The barges used vary in capacity from 2,000 to 20,000 bbl. (42 gal. each) and are equipped with pumps for discharging the oil. Tank cars are built with capacities of 6,000 to 12,000 gal., the most common size being 10,000 gal. For handling the heavy oil these cars are equipped with steam coils, so that they may be readily unloaded in cold weather. Tank trucks of from 1,000 to 2,000 gal. capacity are used for delivery where cars or barges cannot be taken.

Storage tanks may be of steel or concrete and either above or below ground, depending upon their size and the local conditions. They are usually provided with steam or hot-water coils, as the heavy oil should be at about 100 deg. F. to pump easily. These coils are generally supplied by the exhaust from the pump, not much heat being required, since the specific heat of the oil is approximately 0.5. The relative values of steel and concrete tanks have been discussed at great length, but which is the cheaper and better depends largely on local conditions.

The accompanying table, showing the relative value of coal and oil, is based on a constant calorific value for each of the fuels.

RELATIVE VALUE OF COAL AND OIL

Gross Boiler Efficiency with Fuel Oil	Net Evaporation from and at 212° F. per Lb. of Oil	Water Evaporated from and at 212° F. per lb. of Coal				
		6	7	8	9	10
		Barrels of Oil Equal to One Ton of Coal				
75	13.92	2.565	2.993	3.420	3.848	4.275
76	14.11	2.532	2.954	3.376	3.978	4.220
77	14.30	2.498	2.914	3.330	3.746	4.162
78	14.49	2.465	2.876	3.286	3.697	4.108
79	14.68	2.433	2.838	3.243	3.649	4.054
80	14.87	2.402	2.802	3.202	3.602	4.003
81	15.06	2.371	2.767	3.162	3.557	3.952
82	15.25	2.342	2.732	3.122	3.513	3.903
83	15.44	2.313	2.699	3.085	3.470	3.856
84	15.63	2.285	2.667	3.049	3.431	3.813
85	15.82	2.257	2.635	3.013	3.391	3.769

This table is not an accurate basis for comparison, but is useful only as a rough guide for the relative values. The only method of accurately estimating these values is to consider the operating expenses of the plant with each in turn, including the cost of all items entering into the problem. Some of the features to be considered in comparing the two fuels are the space available for fuel storage, the labor saving possible, the number of hours the plant is in operation, the load feature, the quantity of coal for banking fires, etc. The figures in the column headed "Gross Boiler Efficiency" include the steam generated which is used for burning the oil. Gross efficiency, then, is equal to net efficiency, plus the percentage used in atomizing oil. Oil values in the table are based on oil weighing 336 lb. to the barrel of 42 gallons.

Single-Phase Load on a Three-Phase Power System

By J. B. GIBBS

Engineer, Transformer Department, Westinghouse Electric and Manufacturing Company

THE only way to connect a single-phase load to a three-phase power system so that the system will be balanced, without the use of rotating machinery, is to divide the load into three equal parts and connect one part to each phase. There are two ways of making this connection, depending on the voltage of the system and the voltage desired on the load. Fig. 1 shows the delta connection. One part of the load is connected to each pair of line wires, and the voltage

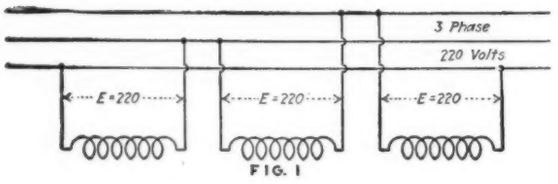


FIG. 1

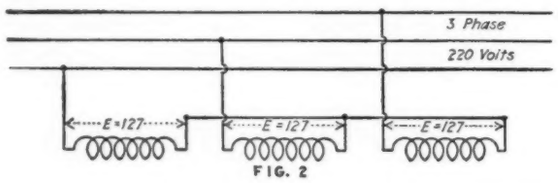


FIG. 2

FIGS. 1 AND 2. SINGLE-PHASE LOADS CONNECTED ON THREE-PHASE CIRCUIT

applied to each part of the load is the voltage between the corresponding lines. With this connection the voltages on the three loads will not be appreciably unbalanced, even if the loads are not exactly equal. Fig. 2 shows the star or "Y" connection. Each part of the load is connected by one wire to one of the line wires, and the remaining three wires from the loads are connected together to form the neutral or star point. If we

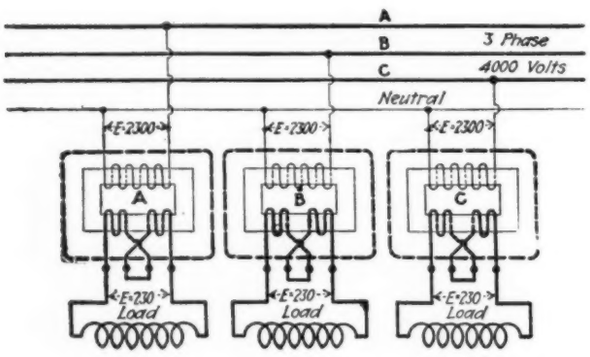


FIG. 3. THREE SINGLE-PHASE LOADS STAR-CONNECTED TO 4-WIRE THREE PHASE LINE

have 220 volts between lines, the voltage on each of the loads will be $220 \div 1.732 = 127$ volts. If the loads, with this connection, are not equal, the neutral point will be shifted and the voltages on the three loads will not be equal.

Another example of the star connection is shown in Fig. 3. The distribution line is three-phase 4000 volts, with a neutral wire, and three standard transformers, with a ratio of 2300 volts to 230 volts, are used to supply three single-phase loads. In this case the star point of the three transformers is tied to the corresponding point of the generator, and therefore the correct voltages will be maintained on the loads even if they are not exactly equal.

If the single-phase load cannot be divided, the best thing to do is to connect it to one phase of the power system and trust to other single-phase loads connected to the other phases to balance the system. As a matter of fact, an unbalanced load is not very objectionable, unless the unbalance is large. A majority of the large generating plants are three-phase, and they carry single-phase loads, distributed among the three phases, as well as three-phase loads. Such systems are never exactly balanced, but never very far unbalanced.

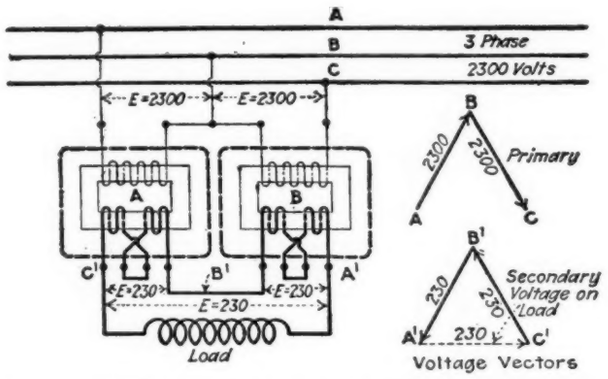


FIG. 4. SINGLE-PHASE LOAD ON TWO TRANSFORMERS CONNECTED OPEN DELTA

Several schemes have been proposed for connecting a single-phase load to a three-phase system, and it may be worth while to analyze a few of them.

1. Open-Delta Connection—It has been suggested that two transformers be connected in open-delta and a single-phase load be taken from the open side, as shown in Fig. 4, the idea being that the single-phase current must flow in both transformers, and therefore in all three lines. Since the load in the secondary windings is single-phase, however, the current in the primary windings must be in the same phase. That is, all the current in the primary of transformer *A* must flow through the primary of transformer *B*, and therefore no current can leave or enter the line *B*. Consequently, we have exactly the same condition as though the load were connected to the lines *A* and *C*, except that it requires two transformers to carry the same load that might be carried by one connected to *A* and *C*.

2. Closed-Delta with One Secondary Reversed—This is shown in Fig. 5, and is similar to Fig. 4, except that it has a third transformer and gives twice the secondary voltage. It will be seen that, since the three secondaries are in series, the currents in the three transformers must be the same, in phase and magnitude. Therefore the current which flows in the primary of transformer *A* is the same as that in transformer *B*, and

none of the current can be carried by line B. The single-phase voltage is the same as though we were using two transformers connected between the lines A and C, but three transformers are being used to give the output which would be given by two connected between A and C.

3. Scott Connection with Secondaries in Series—This arrangement is shown in Fig. 6. The plan is to transform from three-phase to two-phase, and then to connect the two phases in series to get single-phase. This will, of course, give a single-phase voltage, but it is interesting to see what happens when a current flows. For the sake of simplicity suppose that the transformers have a one-to-one ratio, and suppose that each of the two-phase voltages is 100 volts. Then the single-phase voltage will be $100 \times 1.414 = 141.4$ volts. Now suppose that a 10-ampere load is put on the single-phase circuit. Since the primary of the "teazer" transformer B is connected to the 87 per cent. tap, it must carry a current of $10 \div 0.87 = 11.5$ amperes, and this must obviously be the difference of the currents in the two halves of the "main" transformer A. But the total ampere-turns in the primary of A must be equal to the total ampere-turns in its secondary, or 10 amperes $\times$ 100 per cent. turns. Therefore, we have the two equations, 50 per cent. $X + 50$ per cent. $Y = 100$ per cent. $\times$ 10 and $X - Y = 11.5$, where X equals current in one-half of the primary of A, and Y equals current in the other half of the primary of A.

Solving these two equations, we find that X equals 15.75 amperes and Y equals 4.25 amperes. The line C, therefore, will carry 15.75 amperes, of which 11.5 amperes will return to the generator by way of the line A, and 4.25 amperes by way of the line B. The rating of each transformer will be,

$$\frac{10\ amperes \times 100\ volts}{1000} = 1\ kilovolt\text{-}ampere$$

or a total of 2 kv.-a. for the bank, while the total single-phase output will be,

$$\frac{10\ amperes \times 141.4\ volts}{1000} = 1.414\ kilovolt\text{-}amperes$$

We are thus using transformers 40 per cent. larger than we need for the single-phase output and getting as compensation a decrease of 20 per cent. in the line loss,

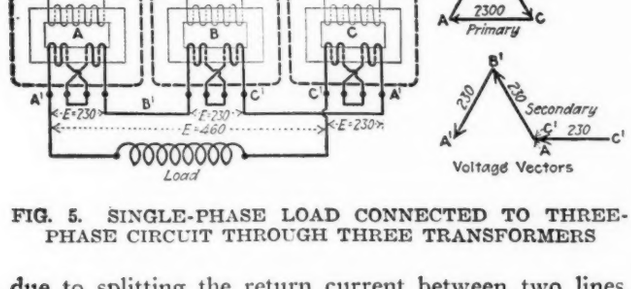


FIG. 5. SINGLE-PHASE LOAD CONNECTED TO THREE-PHASE CIRCUIT THROUGH THREE TRANSFORMERS

due to splitting the return current between two lines. Inasmuch as the line loss is usually a small percentage of the power delivered, a saving of one-fifth of it is seldom worth the extra investment in transformers, especially as these transformers must have a special ratio.

A single-phase load may be perfectly balanced on a three-phase system by means of a motor-generator set, consisting of a three-phase motor and a single-phase generator, but such a set is complicated and expensive, and for this reason it is usually not to be commended. The foregoing may be summarized by saying that a single-phase load can be perfectly balanced on a three-phase system if it can be divided into three equal parts and connected to the three separate phases, or if a motor-generator set is used. The former scheme is frequently possible and advisable. The latter scheme can very seldom be considered, on account of the expense. If neither one of these schemes can be used, it is usually best to connect the load to one of the phases without any attempt to balance it.

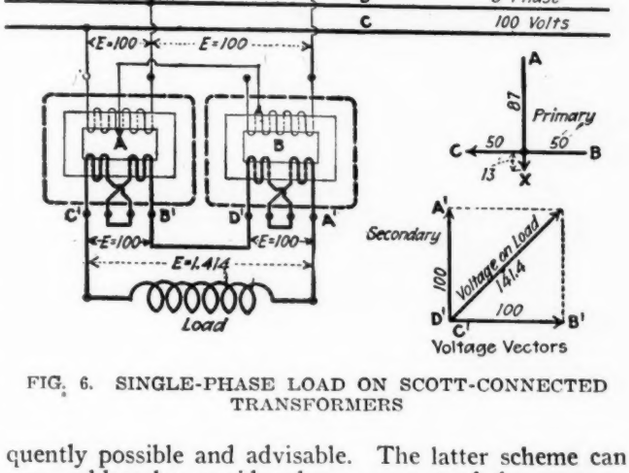


FIG. 6. SINGLE-PHASE LOAD ON SCOTT-CONNECTED TRANSFORMERS

In northern France 30,000 plants, employing 800,000 workers, were razed by gunfire, looted or badly disorganized. In one-half of these plants production has been resumed. While the textile industry is rapidly recuperating, it is estimated that it will require three years for the majority of the principal trades, such as glass-making, woodworking and sugar refining, to resume production on a normal scale. A longer time, probably ten years, must elapse before large mechanical plants, such as the locomotive works at Valenciennes and the coal mines about Lens, can proceed full-speed ahead. Machinery and equipment weighing about 250,000 tons have been returned from Germany, and the French government has advanced to industrial firms credits totaling approximately 3,000,000,000 francs, which sum will be applied against damages estimated in the Chamber of Deputies to amount to 50,000,000,000 francs.

Large hydro-electric undertakings are projected in the Province of Ombria in Italy. It is intended to build two large reservoirs, one on the River Salto, at Baize di Santa Lucia, capable of holding 81,000,000 cubic meters of water; and the other on the River Turano, at Petescia, of a capacity of 132,000,000 cubic meters. Besides subsidiary works and installations of local interest, two generating stations will be built, one utilizing a waterfall at Collestatte 460 ft. high and another at Cervara 200 ft. high, capable of developing a total of 106,421 hp. The developments are estimated to cost $14,000,000, of which about one-third is intended for the subsidiary works.—*London Electrical Review.*

Chief geologist of the United States Geological Survey states that the total available supply of oil in the United States is 6,500,000,000 bbl., which at the present rate of consumption will last between fifteen and twenty years provided no new automobiles are manufactured and no new uses are devised for the commodity.

Parallel Discharge of Centrifugal Pumps

By T. M. HEERMANS
Engineer, Centrifugal Pump Division, Allis-Chalmers Manufacturing Company

To operate successfully in parallel centrifugal pumps should have steep head-capacity curves and the slope of the curves should be about the same. The reasons are simply told and worthwhile pointers are given on the suction pipe.

WHEN a number of centrifugal pumps are arranged to discharge into a common main, there are several ways in which such an arrangement differs from a similar grouping of piston or plunger pumps. These differences are practically all covered under the general head of the difference between the performance characteristics of the two types of pumps. At a constant speed the reciprocating pump, provided the power end is big enough, will deliver a definite capacity into the discharged main notwithstanding considerable variation in the pressure in the discharge line due to starting up or shutting down other pumps discharging into the same line or to other causes.

A centrifugal pump, on the other hand, has a certain fixed curve of relationship between the discharge and the head, so that any change in the pressure in a common discharge main causes a change in the capacity delivered into the main. To illustrate, refer to Fig. 2, which gives the characteristic curve *AC* of a pump designed to operate at point *B* and to deliver 1,800 g.p.m. against a head of 35 ft. If the pressure against the discharge drops to *D* the capacity will be increased to 2,200 g.p.m., or if the pressure in the main increases to *E* the discharge will decrease to 1,200 g.p.m. This

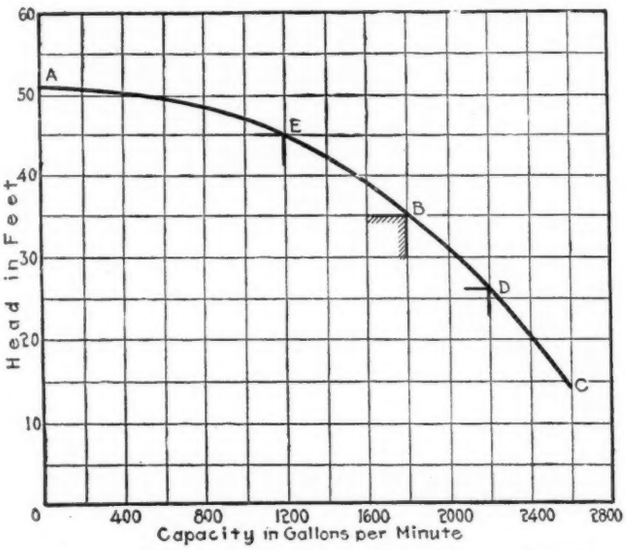


FIG. 2. CURVE SHOWING THAT CAPACITY OF CENTRIFUGAL PUMP VARIES WITH THE HEAD

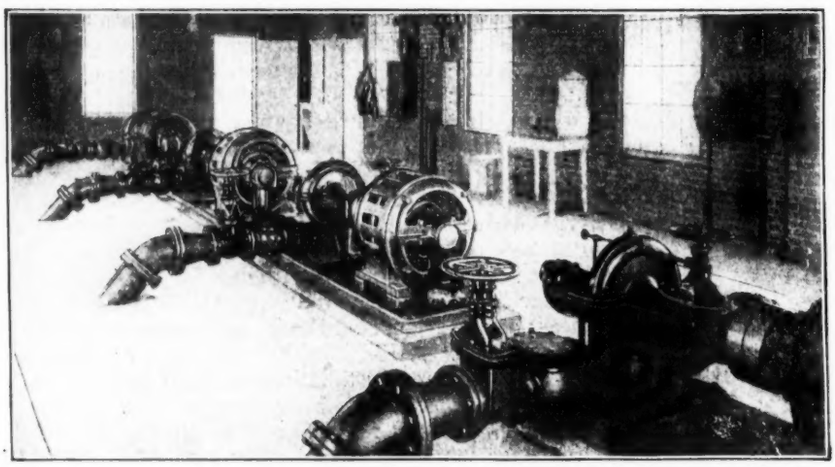


FIG. 1. PUMPS OF 1,000 AND 1,200 G.P.M. CAPACITY OPERATING IN PARALLEL AGAINST A 100-FT. HEAD

means, first, that to work in parallel, centrifugal pumps should be selected that will deliver the desired quantity against about the average head to be maintained in the discharge line under usual conditions.

Second, it would be advisable to specify pumps having runners that will produce the so-called "steep head characteristic" curve, as with this design of pump the capacity will not vary much even if the head in the discharge main changes considerably.

Third, the several centrifugal pumps that are to discharge into the common main should have head-capacity characteristics as nearly alike as possible in so far as the proportion of change in capacity for a change in head is concerned; that is, the slope or steepness of their head-capacity curves should be about the same. When purchasing new pumps that are to discharge into the same main with existing pumps the foregoing statement means that the manufacturer should be supplied with the characteristic curves of the existing pumps. This can again be best illustrated by the curves, Fig. 3.

Suppose two pumps have been selected each having the normal rating indicated by point *P*, but having head-capacity curves of different type such as *A* and *B*. If, for any reason, the head in the discharge main should increase from *H* to H_1 the capacity of pump *A* would be decreased only to *C*, whereas the capacity of pump *B* would be decreased considerably more, or to *D*, a much less efficient operating point on the curve. The point of maximum efficiency of a centrifugal pump properly selected is at about the rated head and capacity. The pumping work at the changed head conditions is therefore unevenly divided between pumps *A* and *B*, and the over-all pumping efficiency is reduced. If both pumps had the same type of curve, the pumping work at increased head would have been equally divided and the combined pumping efficiency would have been correspondingly higher.

Fig. 3 illustrates one other point; namely, that should the head in the discharge main be increased to H_2 the "shutoff" pressure of pump *B* would be exceeded and it would not deliver any water at all, but would merely churn the water in its casing. This indicates the necessity of selecting a pump for parallel operation with a head curve steep enough so that the starting up of additional pumps will not increase the pressure in the main above the shutoff pressure of one of the pumps, thereby stopping the discharge of that pump.

With a little care it is not a difficult matter to select centrifugal pumps that will operate just as satisfactorily in parallel as any other type, with the additional advantages peculiar to the centrifugal pump of smooth, nonpulsating delivery, impossibility of excessive pressure rises in the mains, simplicity and low maintenance and operating expense.

In connection with the parallel operation of centrifugal pumps it might not be amiss to add a few remarks about the suction pipes. These should be of liberal sizes to reduce friction to a minimum and should be absolutely free from air leaks. It is also advisable, whenever possible, to connect the suction pipe to the pump with a short length of straight pipe next to the pump or a straight reducing fitting reducing from a larger-sized suction pipe to the size of the pump suction opening.

An elbow connected immediately to the pump suction causes the water to whirl in entering the pump and makes a disturbed flow at this point and sometimes unbalanced pressures on the two sides of

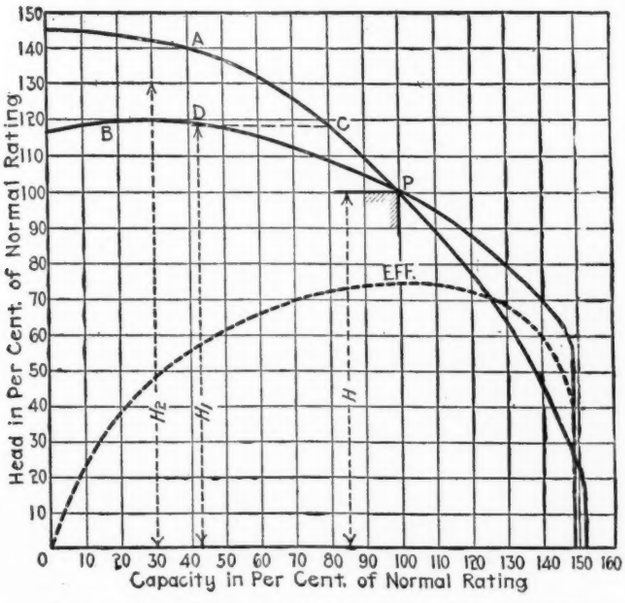


FIG. 3. EFFECT OF VARIATION IN HEAD ON TWO PUMPS HAVING DIFFERENT CHARACTERISTICS

double-suction runners, which it is just as well to avoid. In using a straight reducer to connect the suction pipe to the pump, this reducer ought to be of the eccentric type so as to avoid the air pocket shown in Fig. 4.

When two pumps are discharging into the same main and drawing out of a common suction well, it is a good plan to have independent suction pipes rather than a common suction main. If the latter is used, however, it should be of large diameter and the suction branch to each pump arranged so the friction in each will be as nearly equal as possible. Otherwise one pump will draw water easier and consequently pump more than the other. All suction pipes should be immersed sufficiently deep to prevent air being drawn into the pump. Pump-suction pipes should not

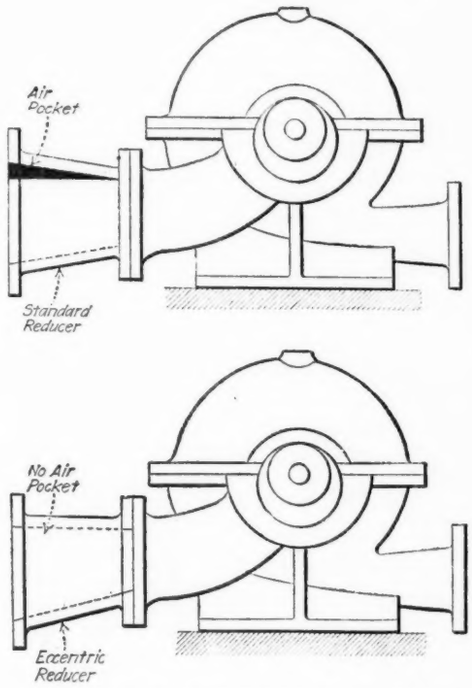


FIG. 4. COMPARISON BETWEEN STANDARD AND ECCENTRIC REDUCER IN PUMP SUCTION

be placed so near to each other that the suction of one pump interferes with the flow of water into the suction pipe of the other. Also the discharge from the tail pipe of a condenser or an overflow back into the sump near the suction of a pump often carries air into the water, which is taken up in the pump suction pipe and reduces the capacity. Pump suction pipes should not be placed with their lower extremities too near the bottom of the suction well, as this increases the loss at entrance and also causes sediment to be drawn up into the pump. Foot valves, if used, should be of liberal size and free from obstructions.

If centrifugal pumps operating in parallel seem to be performing unsatisfactorily and the precautions mentioned in regard to the discharge conditions have been observed, it would be advisable to investigate the suction-pipe layout along the lines just indicated.

Crude oil and gasoline have again advanced in price in California, according to an announcement by K. R. Kingsbury, president of the Standard Oil Company of California. The price of crude has been increased twenty-five cents per barrel for all grades and the price of gasoline has increased two cents per gallon. The Railroad Commission of California, in a letter to Mr. Kingsbury, demands an explanation of the necessity for the increase on the ground that it is officially interested in the increased prices of crude oil inasmuch as it will mean an increase of electric and gas rates in California of several million dollars.

New Kern River No. 3 Construction Work

By H. W. Dennis*

Kern River Number Three is not unlike, in its general plan, many of the other hydro-electric developments of the Southern California Edison Company. This general plan includes a comparatively low diverting dam, a conduit line consisting of flumes and tunnels, the appropriate pressure mains, and the power house with its apparatus. The project differs from some of the others, particularly the early ones, in that every part essential to continuous and uninterrupted operation has received especial attention to permit that result with minimum maintenance. It has the further difference in that the prime movers are hydraulic reaction turbines whereas most of the other plants use impulse waterwheels. It has the especial distinction that the turbines will operate under a higher head than any other reaction turbines in the world.

There is no reservoir at the intake of this plant, and therefore the dam is only so high as to accomplish the diversion of the water. Nevertheless it is a concrete structure, founded on bed rock. For about one-half of its length its height varies from 8 to 20 ft., but for the remainder the maximum height is nearly 60 ft. where it closes an old channel deeply eroded in the ledge. The intake structure has trash racks, head gates and sluice gates and, in addition to these usual features, there is a protecting wall with openings below the crest level of the dam so that the water may enter for the plant and the floating débris will be diverted over the spillway. The dam with the intake structure is finished.

Removing the Sand from the Water

All of the streams flowing from the Sierras carry large quantities of sand which must be removed before the water reaches the wheels. Without this removal the scouring effect would produce rapid deterioration of the turbines with consequent reduction of efficiency. The sand box, located between the dam and the first tunnel, because of its large dimensions, is expected to arrest all gritty particles except those that are fine enough to remain in suspension for a long time. There are two compartments so that either may, if necessary, be entirely unwatered without interrupting the flow to the plant, but generous sluicing facilities are provided for blowing out the sand without resorting to the unwatering process.

By far the major portion of the conduit is a series of tunnels whose aggregate length is nearly 60,000 ft., the longest single one being 7,132 ft. between termini. Each tunnel is connected to its neighbor by a concrete flume which is either built on a bench, in the side of the mountain, or in a cut where the cover was insufficient for tunnel construction, or in the air supported by reinforced concrete bends where it was necessary to cross certain gulches. The tunnels are lined with concrete on the sides and bottom, but are not lined for the roof except where necessary for supporting the material above. In order to secure a smooth surface for the water contact, steel forms are being used with gratifying results. For the upper nine miles of the conduit the finished size of the tunnel is 8.5 ft. wide and 8 ft. for the height of the side walls. The water will be about 7.5 ft. deep running at a slope of 2 ft. per thousand. For the remainder the width is 9.5 ft. and the slope 1.5 ft. per thousand, the depth being the same throughout. The capacity will be 600 cu.ft. per second.

A mile above the forebay the conduit line crosses Little Brush Creek at a point where the tunnel grade is 300 ft. above the creek bed. To have made this crossing at grade would have involved a long detour adding nearly a mile to length of the flow line, and accordingly an inverted siphon was decided upon. This part of the work is nearly complete. It required 470 tons of steel pipe whose diameter at the top is 9.5 ft., where the pressure is least, and 8 ft. at the bottom where the pressure is greatest.

From the forebay the water will be conducted to the power house through two steel pressure mains involving 1,260 tons of steel pipe varying in size from 7 ft. in diameter and $\frac{3}{8}$ in. in thickness at the top where riveted pipe is used to 5 ft. in diameter and 1 in. in thickness at the bottom where lap-welded pipe is used. Expansion joints are provided at appropriate places and venturi meters are to be installed in each line. These meters measure the amount of water flowing by noting differences in pressure and velocity, although offering no obstruction to the flow and give, by comparison with the electrical output, continually a means of knowing whether any undue deterioration has occurred within the prime mover.

Details of the Generating Unit

The distinctive feature of the Kern River Three station is the generating unit itself. No other hydraulic reaction turbine in the world operates under a head as high as this, namely, 800 ft., nevertheless bountiful assurance has been given that no mistake is being made in the adoption of this type of waterwheel for these conditions. Another especial feature lies in the provision for changing the turbine runner to permit changes in speed to produce either fifty-cycle current for southern California or sixty-cycle current for the San Joaquin Valley. The frequency changer to be installed at Vestal is necessary in addition to this arrangement at Kern River Three and is far smaller than would otherwise be required.

The generating units will be two in number, rated to give 22,500 hp. each at a speed of 600 r.p.m. for sixty cycles and 500 r.p.m. for fifty cycles. Strike conditions at the works of the turbine manufacturers have caused delay in the building of the waterwheels.

The generating voltage is to be 11,000 and step-up transformers will raise this to 75,000 volts for the outgoing lines for which there are to be two circuits of 4-0 stranded copper, which will deliver the output into the rest of the system at the new substation at Vestal, in the San Joaquin Valley near Richgrove.

The facts that 25,000 tons of freight have already been delivered 50 miles over mountain roads and 2,500 men have been engaged upon the work will merely indicate the magnitude of these special problems. The length of the conduit line is more than twelve miles and most of the construction is through the hard rock of the Sierras. The assignment was given out a number of years ago, and until 1914 the work progressed slowly, consisting principally of road and trail construction and hand excavation of tunnels. An electric transmission line was built in the fall of that year to supply construction power. It is only a little more than a year ago that major activities were commenced looking to the early completion of the development.

*Construction engineer Southern California Edison Co.

EDITORIALS

The Coming National Engineers' Organization*

WHAT form is the nation-wide organization of engineers which is in the process of evolution going to take?

In the many minds which are active in the movement there is a multiplicity of ideals, with many variations as to detail but resolvable into two distinct schools.

One group conceives a broad all-inclusive engineering society to which anybody who has a legitimate connection with or interest in engineering may belong, subject, of course, to his approval and acceptance by the local unit to which he applies for membership. The local unit would bring together the engineering personnel of a community and serve as the medium for the expression and impression of the collective thought and experience of its members upon the engineering problems and activities of the neighborhood. Its meetings would deal with such subjects as would hold its members together through a common interest, unify them as an organized force for public service and emphasize the importance of the engineer as a factor in the communal life, as other professional and business organizations have done for their constituencies. The national association would be the aggregation of these local bodies. Every member of a local would be a member of the national body, but the opinions and policies of the larger body would find expression and definition in a representative convention and be carried out by an executive council and a secretarial organization. This plan does not contemplate any interference with existing organizations. The national professional societies with their more specialized and selected membership would continue to serve their respective branches of the profession after their own manner, and their local sections, as well as independent local and regional societies, clubs, etc., would preserve their autonomy, although, for activities general in character, their members would look to the all-inclusive local society.

The other school contemplates, rather, a federation of existing societies. The local organization would consist of a council or committee made up of representatives from such of the local clubs, societies and sections of the national societies as were invited to join. These committees would arrange for joint meetings and correlate the activities of the constituent bodies in matters of common interest. Representatives from the local councils or committees and of the various national and regional societies would form the federal body, of which the individuals composing the constituent societies would be members only in the sense that a member of the civil, mechanical, electrical or mining engineers is a member of the present Engineering Council.

The one plan contemplates the bringing together of the entire engineering profession and craft of the country into a new, broad, inclusive, democratic organization. Membership in it would not confer that distinction which leads to the use of such suffixes as M. I. C. E. That would continue to be a quality of the more exclusive professional bodies. But it would bring together a very large body, numerous in inverse proportion to the stringency of the entrance requirements, for public service and for putting the engineer upon the map. The other contemplates the banding together through selected representatives, of existing bodies for purposes of interest to them all. Nobody could belong to it except as a member of one of the societies of which it would be formed, and such membership would give only a very remote delegated interest in the national body. The proponents of the first plan claim that it is the more democratic, those of the second that theirs is the more capable of realization.

The Joint Conference Committee of the four great national professional societies has been instructed to call a meeting of the various national, regional and local engineers' organizations for the purpose of effecting a general organization and such a meeting is expected to be called in Washington in June. It is to be hoped that a broad and liberal spirit will be shown in inviting representatives to the initial meeting. The plan of the Joint Conference Committee is rather of the federation than the all-inclusive type, but is, as we understand it, offered to the congress of societies which is to be called as a suggestion rather than as a finality, and it is the congress which, in its collective wisdom, will determine what form the organization shall take.

We have attempted to outline the extremes of the two types of organization. Between them there is a multiplicity of possible combinations. Perhaps, as Mr. Marburg suggests, the constitutions of the locals need not be all alike.

*Comments by L. C. Marburg, chairman of the Committee on Aims and Organization of the American Society of Mechanical Engineers and representative of that society upon the Joint Conference Committee, will be found on page 559.

Engineers Who Use Turbines Should Have a Voice in Their Design

ASSUMING an average cost of three hundred dollars per kilowatt of generating capacity to cover the entire cost of a central-station system from coal pile to customer's meter, there is an investment of over two billion dollars in the United States dependent on turbines of ten thousand kilowatt capacity and larger. This amount is too large to be subject to any differences in fundamental principles between the manufacturers' engineers.

In the industrial field there are at present no turbines larger than ten thousand kilowatts in operation. It is therefore evident that the development of large sizes is of the greatest interest to public utility corporations.

The turbine designers should not be called on or permitted to assume all the responsibility for initiating new types of design, increased capacities or change

in operating conditions without the help of the central station engineers and the operating men, who should take a stronger position in the matter of controlling operating conditions and the development of the turbine as to type and capacity.

There should be agreement between manufacturer and user of turbines on such matters as:

1. A uniform rating of turbines.
2. Standard steam conditions with correction factor for other values.
3. Economic size of turbine recommended for a specified service.
4. Standardization of operating methods.
5. Uniform systems of inspection.
6. Actual efficiency of representative types and sizes of turbines.

The central station men have had many years of operating experience with steam turbines and they can do much to advance the progress of the art. There are over one hundred engineering societies and associations doing standardization work to some extent on items covering every manufactured product in the United States except the steam turbine. The greatest deterrent today in the progress of the development of large steam turbines is the failure of manufacturers to exchange patent licenses, and use the salient points of each other's design. The turbine is practically the only apparatus in which this is not done. The manufacturers of large steam turbines should build a standardized combination type.

National Board of Boiler and Pressure Vessel Inspectors

THE National Board of Boiler and Pressure Vessel Inspectors, which has come quietly into existence, has potentialities which, properly developed, will make it a powerful factor in reducing the loss of life and property through boiler explosions and in unifying and standardizing boiler practice in the United States. The board is composed of the heads of the boiler-inspection departments of all the states which have adopted the American Society of Mechanical Engineers Boiler Code or into which boilers built to the Code are admitted. There are fifteen such states at present.

The opportunities for co-operation afforded by this tying together of the different state departments are many. The Boiler Code Committee lays down general rules and specifications, but does not pass upon specific designs or construction. It is the province of the state inspector to say whether a given design or appliance or practice is safe or not. The confusion which would arise from different decisions from different state inspectors will be avoided when the departments are in sufficiently close touch to consider such questions collectively and settle them alike. Under the Code a boiler must be inspected during construction and, upon completion, stamped by a qualified inspector, showing that it is in conformity with the standard. The National Board affords the machinery through which the stamp and certificate of the inspector of the state in which the boiler is built can be made valid to the inspection authorities of the distant state to which it is transported. The compilation of the records of the different state departments will give for the first time reliable statistics of the number of boilers in use, the number of explosions and serious accidents. They will indicate the most prolific causes of trouble and suggest the directions in which the Code should be revised the better to fulfill its purpose. It is easy to foresee that, as more and more of the states adopt the Code and the Board grows in numbers and influence, its convention will be one of the most important happenings of the year in boiler circles.

The Worm Commences To Turn

THE Railroad Commission of the State of California has dared to tell the president of the Standard Oil Company that the reasons assigned for its increase in the price of crude oil are inadequate, and to declare that if private control of prices is justified, it must be justified on the ground that the private control is reasonable and is not unduly or unfairly burdening to the public.

The names of the members of the Railway Commission of the State of California are: E. O. Edgerton, H. D. Loveland, Frank R. Devlin, W. Brundige and Irving Martin.

Watch what happens to them!

What would fuel oil and coal cost the user if he had to pay nothing more than the cost of mining, preparing and distributing it, plus a fair interest on the capital actually employed and a fair profit?

An increasing number of people—big people, even people who in their official capacity are supposed to hold a brief for the consumer—are commencing to ask this question and to demand an open accounting and a price based upon cost rather than upon a control of the supply and the urgency of the demand.

Uncle Sam had some oil lands of his own, but the plan of letting private "enterprise" develop them has been so successful and satisfactory (to the developers) that he has just turned over to them a good tract cut of the little that he had left.

The American Library Association is planning a greatly enlarged program for the extension of library service throughout the country. The association, organized forty-four years ago, at present has a membership of four thousand active librarians. One of the important objects of enlargement is the more extensive use of technical books now in the public libraries and the installation of circulating libraries in industrial plants. It is planned to inaugurate a drive to raise two million dollars to carry on the work. The value of circulating libraries of technical literature in power plants and factories for the use of employees should not be underestimated. Not only will the employer benefit by the increased efficiency of his employees, but the men will fit themselves for better and more responsible positions. The greatest problem of the day in every industry, due in part to labor shortage and increased wages, is ways and means of securing larger production. This can be accomplished to a certain extent by increasing the efficiency of employees through educational methods of libraries at the plants. A number of far-seeing manufacturers have realized the importance of technical books dealing with their particular branch of industry and have installed special libraries in their plants.

In some quarters there is discussion as to which travels the faster—light or the price of fuel oil.

CORRESPONDENCE

Preserve the Autonomy of Local Organizations

I have read with great interest your editorial on the coming National Engineers Convention.

Your outline of the two alternative plans is very interesting. However, allow me to call attention to the fact that as far as I know nobody proposes the extreme plan of federation which you outline. The fact is that, in some localities, engineering societies at present exist, which have individual members and who have affiliated with them the sections, associations, etc., of national societies. In such municipalities as, for example, Milwaukee, an individual engineer need not join any of the affiliated organizations, but can join the local engineering society.

In other localities, for example, in San Francisco, the plan of local organization is actually in accordance with your sketch; namely, there exist a number of sections of national societies, and I believe also local organizations that have formed a local representative council.

In still other localities, like Philadelphia, we find a local engineers club, which is a social club, but is at the same time, and really mainly, the engineering forum of the particular community. In this case the club has affiliated with it sections of national societies and in some other localities also certain local engineering organizations. In such a municipality an engineer would have the alternative of joining the club, which, of course, has fairly high dues, or joining one of the affiliated organizations.

The fundamental idea of the plan of the Joint Conference Committee is that the National Council should not concern itself with the type of organization adopted locally and that it should admit to the National Council any delegate reasonably representative of the engineers of a particular community. The whole plan of organization is based on the local units, and the local units ought to be autonomous as long as they do not encroach upon the rights of other local units. Furthermore, the local society or affiliation can select its representative on any basis it sees fit. If it decides to elect it by the vote of all the engineers making up the local engineering society or affiliation, surely the National Council, according to our plan, will have nothing to say about it; in fact, I believe the majority of the members of our committee would be much in favor of such a plan, but do not feel that the National Council should prescribe anything that would interfere with the full autonomy of the local organization. As far as the election of a representative on the National Council is concerned, the two plans sketched in your editorial are, therefore, not different, and the relations of individual members of the local organizations to the National Council can be just as close with our plan as with the other plan outlined, if the engineers of any locality choose to have it so.

In one paragraph of your editorial you speak of bringing together, by means of the other plan considered, "a very large" body of engineers. One of the reasons why we favor the plan proposed by the Joint Conference Committee is that we are firmly convinced our plan will bring together, within a reasonable time, a very much larger body of engineers than any independent society could hope to bring together.

New York City. L. C. MARBURG.

Merits of Chain and Ring Shaft Lubrication

It has been my experience that the ring method of lubricating a bearing is very efficient. I have known ring-oiled bearings that had a little new oil added only once in about two months, to run for over two years without being drained, and then the oil looked clean. One precaution that should be taken with ring-oiled bearings is to see that the rings begin to revolve when the shaft does, as sometimes the rings fail to start. I have never known the rings to stop once they started, unless the shaft stopped revolving.

I much prefer the ring to the chain method. In my experience I could not depend on the chains at all because the links would get tangled and they were liable to stop at any time. CLAY WINEBERG.

Widnoon, Pa.

Reboring Corliss-Valve Chambers

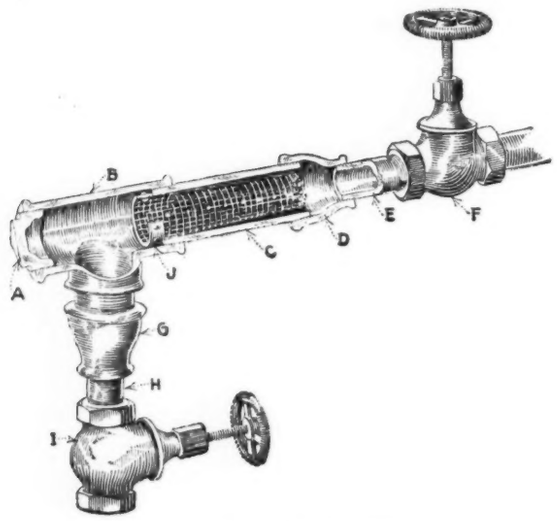
In answer to Mr. Murphy's inquiry in the Feb. 17 issue of *Power*, page 274, regarding reboring Corliss-valve chambers, I have rebored quite a number, and in every case I have paralleled the boring bar with the original counterbore recessed in each end of the valve chamber.

I frequently set my bar low centrally, but always parallel, so as to clean and true the valve seats by the time the cutting tool is just scraping the top of the valve chamber, thereby reducing the diameter of the valve to be refitted. DAVID G. YOUNG.

Hudson Heights, N. J.

A Good Water-Line Strainer

A good cheap strainer, to be used in water lines, can be made from a housing of pipe fittings. For a 2-in. water line I use a 4-in. plug *A* and tee *B*, 4-in. nipple *C*, reducer from 4 in. to 2 in. *D*, 2-in. nipple *E*, 2-in. globe valve *F*, bushing *G* from 4 to 2 in., 2-in. nipple *H* and



DETAILS OF STRAINER

a 2-in. globe valve *I*. The sketch of the strainer housing and connections will need no further explanation.

A few words in regard to the make-up of the strainer may be helpful to anyone interested enough to give it a trial. I first selected some galvanized screen wire, with suitable mesh for the desired results; for instance, about $\frac{3}{16}$-in. mesh for feed water going to the open heater. I cut a piece 7 x 23 in. The idea of cutting the screen wire 23 in. long is in order to give it double strength. I then rolled it up so that the top end was a little less in diameter than the 4-in. nipple at the top end, and the bottom end about $\frac{3}{4}$ in. less in diameter, so as to give the water a chance to flow through the outside of the strainer as well as out at the bottom.

With the strainer body rolled to the proper size, I tie a cord around it to hold it in position; then I make a band for the top end, about $\frac{3}{4}$ in. wide by $\frac{1}{8}$ in. thick, with holes drilled all around, about one inch apart. I place this band over the end of the strainer and copper rivet it through the mesh of the strainer, and also rivet along the side. Next, I cut a piece of the screen about $1\frac{1}{2}$ in. larger than the diameter of the bottom end of the strainer, nick the edge with a pair of snips so that it can be turned up about $\frac{3}{4}$ in. all around, insert on the top end of the strainer and rivet with five or six copper rivets.

It is necessary to have a bail for the removal of the strainer for cleaning, etc. I made the bail from a piece of 12-gage wire, the ends being hooked through two extra holels that are drilled in the band for that purpose. The bail should be long enough to reach close up to the plug. To insert or remove the strainer, just take out the plug. Notice that the strainer should pass on through the tee *B*, and into the 4-in. nipple with the edge of the band *J* snug against the end of the 4-in. nipple *C*, as shown.

J. R. WEBB.

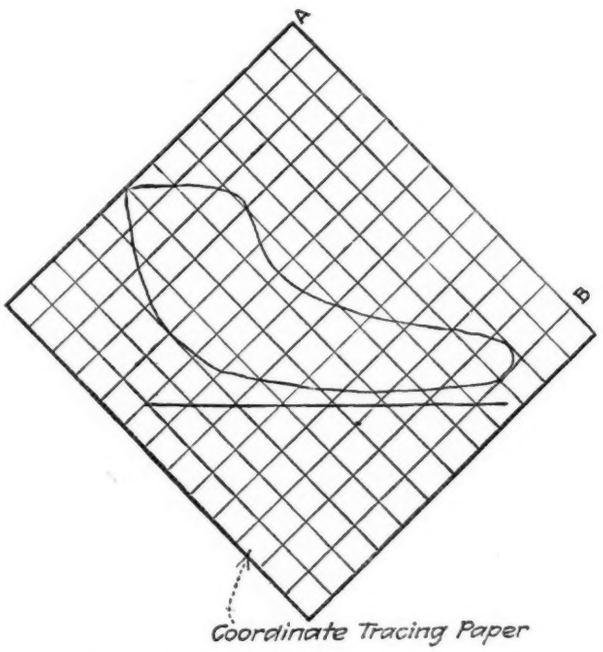
Parkersburg, W. Va.

Measuring an Indicator Diagram

A simple method of measuring an indicator diagram is to take a piece of ordinary coördinate tracing paper, which is marked off in inches, usually in tenths of an inch. This paper is laid out very accurately and can be purchased at almost any stationery store.

Lay this tracing paper on top of the indicator card in such a way that any two lines—for example, lines *A* and *B*—fall tangent to the extreme ends of the diagram, as shown in the illustration. The rest is easy. Simply follow the usual instructions for performing the more laborious method. The difference is that here we have the lines already prepared for us and accurately spaced and drawn. Better still, these lines are arranged in squares, which makes it possible to estimate areas with the eye very accurately. Thus if the lines are one-tenth of an inch apart, the area of each small square is one one-hundredth of a square inch. Hence, if a half of a small square falls within the area of the diagram, the reader can estimate that much of the area with his eye with surprising accuracy.

For example, it may be found that the left end of the diagram includes portions of two squares and that each portion is approximately one-half of a hundredth of a square inch. The total area for the ordinate therefore would be, one hundredth of a square inch. The next ordinate may include two complete squares and a half of a square, making the total area 0.025 sq.in. In this way the columns or ordinates are added from



CO-ORDINATE PAPER USED TO MEASURE INDICATOR DIAGRAMS

left to right, and the sum total of them all gives the area of the diagram. It is obvious that with squares laid out in tenths of an inch instead of eighths of an inch or sixteenths of an inch, the process is considerably simplified. The best way to understand this method and fix it in one's mind is to do it; then it will not be forgotten.

W. F. SCHAPHORST.

Brooklyn, N. Y.

A Freak Metering Problem

A two-story building was originally wired for a three-ire service, the upper floor being fed from one outside ire and neutral and the down floor between the other utside wire and neutral, as in Fig. 1. Then the service as changed to two-wire by simply jumping the two utside wires together at the entrance and installing a wo-wire meter, Fig. 2. Still later another change was nade in the building, and two circuits, each with a

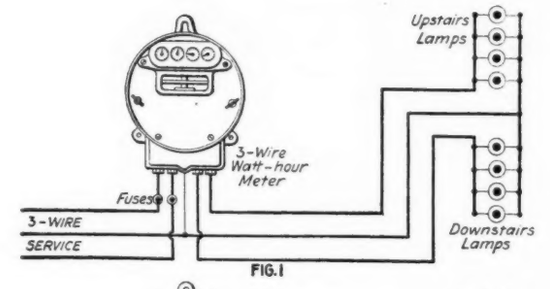


FIG. 1

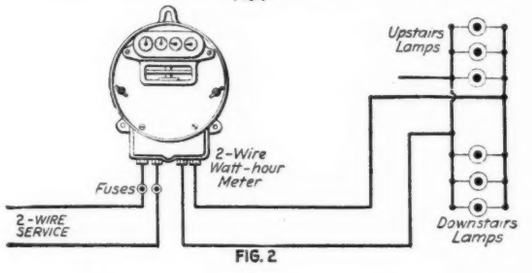


FIG. 2

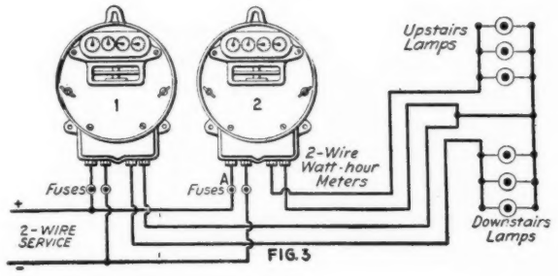


FIG. 3

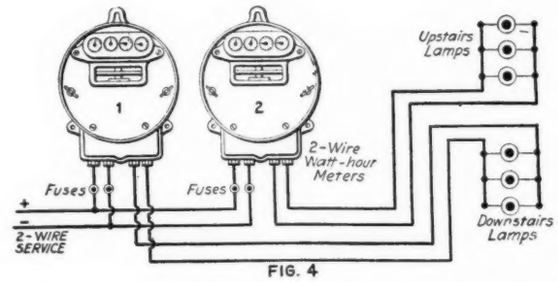


FIG. 4

FIGS. 1 TO 4. GIVE DIFFERENT CHANGES MADE IN METER AND CIRCUIT CONNECTIONS

meter, were provided, as in Fig. 3. Then the trouble started. The tenant on the second floor claimed his bill should not be as large as that of the tenant on the first floor, since the latter had a lighting and power load, where the upstairs tenant had only lights. Another point noted was that the bills for both upstairs and downstairs were practically the same each month, although these varied from month to month. Tests showed that the meters were recording properly when tested in the usual manner. This went on until one month the tenant downstairs had a large bill and the one upstairs had none, although no complaint was made that the service was off. Suspecting that grounds were the cause, tests were made which disclosed the following results:

The wiring had never been changed except at the visible portions of the meter board, which left it three-wire and made only two circuits for the meters. The result was that the two meters were actually in parallel, and if the tenant upstairs used a greater number of lights, the downstairs tenant paid for half of it. When the fuse at *A*, Fig. 3, blew out, meter No. 2 stopped and meter No. 1 recorded the total load. Having found the cause, it was easily remedied by connecting the meters in their respective circuits, as in Fig. 4.

Orange, N. J. VICTOR H. TODD.

The Need of Competent Engineers

A good illustration of what may be expected from an incompetent engineer was to be found in an ice-making plant of which the writer took charge after it had been shut down for two or three months during the off season. The engineer had quit about the middle of the operating season. The manager, being one of the penny-wise and dollar-foolish type, placed in charge a fireman who had never been in an ice plant before that season. To finish the season's run, he operated the plant for about two months and left it in the condition pictured in the following:

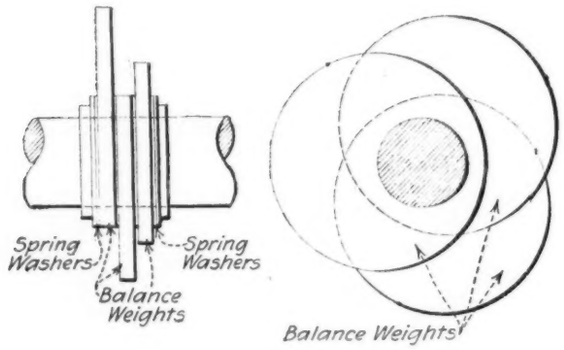
After trying to put ammonia in the system and shipping back the cylinders to the ammonia dealer, the ice company got credited for more ammonia than was purchased. He had actually taken ammonia out of the system instead of putting it in. One of the boilers had been allowed to run so long without cleaning that the sheet over the fire became bagged. Instead of getting an experienced boilermaker to drive the bag up, he tried it himself with the result that the sheet was injured. The former engineer left the engine in good condition, having used an indicator to set the valves and make adjustments. They operated economically and without a pound. When the writer took charge of the plant and used the indicator, it could not be told whether the diagram was from a duplex pump or a Corliss engine and the pound could be heard for blocks. Most of the pumps in the plant were out of commission. Two-thirds of the tubes were leaking at the back ends of boilers, and in numerous places the scale between tubes was solid for two to three feet from the back end. The combustion chamber was filled with ashes level with the top of the bridge-wall. The feed-water heater was scaled so badly that its use had been discontinued and cold water had been fed into the boilers from the city mains. Conditions in general were about the same throughout the plant.

This is one plant that came under the writer's observation, and no doubt there are many others in equally bad condition for lack of competent engineers. I do not say that the man in question was altogether to blame. He probably did the best he knew, but he was incompetent. Such conditions should not exist, and any manager who will permit them should be prosecuted for criminal carelessness. It all means that Kansas, and in fact every state in the Union, should have a good license law, or better still, a national license law that would be uniform throughout the country. Then every engineer would be placed on the job he could operate successfully. JOHN DOE.

Concordia, Kan.

Balancing Steam Turbines

The vibrations that occur in machines when getting up to what is commonly called the critical speed point to possible improvements, because in spite of every care taken during manufacture these speed periods crop up, to the detriment of the machinery. The makers must consider the running balance of the machines, not only when new, but after they have been running for some time and the blading has become



COMPENSATING BALANCING WEIGHTS

eroded, etc. It is then that the machine is likely to get more out of balance and cause trouble, unless it is rebladed, which work cannot always be done as soon as it should.

The cure seems to lie in automatic compensating balance weights that will adjust themselves when running to take care of any unbalanced forces. The illustration shows front and side elevations of such an arrangement. It will be seen that there are three eccentric-shaped weights between two collars, having spring washers. These weights should be a neat fit on the shaft and should be turned by hand without any perceptible wabble.

The spring washers are for the purpose of turning the weights around with the shaft. They must not press tight enough to prevent the weights from adjusting themselves around the shaft, nor yet be slack enough to let the weights slip and not revolve.

There is nothing new in this system of balancing, it having been applied over twenty years ago and seemingly forgotten. The action of the weights is to adjust themselves around the shaft on the lightest side, thus balancing the machine and dampening down the vibration. This system could also be applied to generators and motors, using weights made of nonmagnetic material.

Winnipeg, Canada. O. G. A. PETTERSSON.

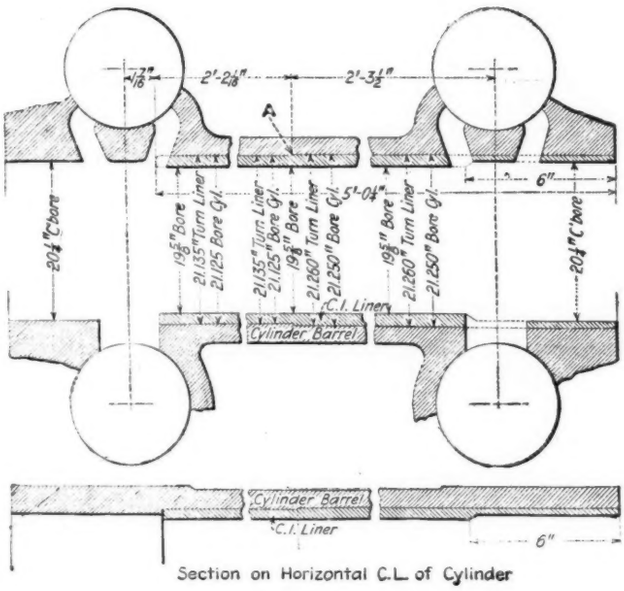
Steam-Engine Cylinder Liners

In our central-station plant we had two 20 and 40 by 48-in. cross-compound engines each direct-connected to a 500-kw. generator. The cylinders were a 4 to 1 ratio, which was all right for running condensing, but we had to operate non-condensing and against the back pressure of a city-heating system.

It was decided to change to a 3 to 1 cylinder ratio by putting in a liner. The cylinders were bored to make sure they were true, the head end of the cylinder being bored $\frac{1}{8}$ in. large for half the length of the cylinder to facilitate the insertion of the liner. The cylinder bore was made ten thousandths of an inch smaller than the outside diameter of the liner.

All the valve gear was removed and a charcoal fire built in the cylinder. When the cylinder had expanded sufficiently, the fire was swept out and the liner slipped in. After the cylinder had cooled, the liner was found to be tight and has remained so ever since. The engines now are 20 and 34 by 48-in. and operate against 10 lb. back pressure and carry full load.

The high-pressure cylinders of these engines, as they became worn, were rebored so many times that they finally became too thin to bore further and have



SECTION OF CYLINDER AND LINER SHOWING BORE DIMENSIONS

them still stand the pressure. The liners in the low-pressure cylinders had worked so well that we decided to try the same thing on the high-pressure side. While on the low-pressure side the liners were 3 in. thick, those for the high-pressure cylinders could only be about $\frac{5}{8}$ in. in thickness without reducing the cylinder bore.

The liners were made of semi-steel and roughed out at the shop. In boring the cylinder, the last cut was run just halfway in, as shown at *A*, thus permitting the liner to be inserted halfway before coming to a fit. The cylinder bore was calipered and the liner turned down to ten thousandths of an inch larger than this. The ports were laid off on the liner and a row of $\frac{1}{4}$-in. holes drilled around the edge of where the ports were to come. These pieces were left in until the liner was in place, after which they were knocked out with a chisel and hammer. The liners were installed in the same manner as already described.

This work was done six years ago. The engines have been operated from 20 to 24 hours every day and are giving entire satisfaction. The cost of putting in these liners was less than $500, whereas a new cylinder would have cost around $5,000. H. T. YUST.

Ottumwa, Iowa.

INQUIRIES OF GENERAL INTEREST

Allowances for Shrink Fits—What allowances of oversize is generally made for shrink fits? B. J. B.

In good machine shop practice the allowances made for shrink fits are about as follows:

For 1 in. dia.,	0.001 in.	For 10 in. dia.,	0.0053 in.
For 2 in. dia.,	0.0015 in.	For 12 in. dia.,	0.0058 in.
For 3 in. dia,	0.0020 in.	For 16 in. dia.,	0.007 in.
For 4 in. dia.,	0.0028 in.	For 20 in. dia.,	0.008 in.
For 6 in. dia.,	0.0035 in.	For 24 in. dia.,	0.0093 in.
For 8 in. dia.,	0.0045 in.	For 28 in. dia.,	0.0105 in.

Induction-Motor End Rings Melted—A 3-hp. 220-volt three-phase squirrel-cage induction motor driving a compressor was stalled on account of failure of the valves. On inspection the rotor bars at the end rings were found to be melted, yet the 30-ampere fuse which protected the motor was not blown. Should not this fuse have properly protected the motor when it was stopped? J. H. W.

A 3-hp. 220-volt three-phase squirrel-cage induction motor will require a full-load current of about 9 amperes per terminal. Therefore, a 30-ampere fuse would allow the motor to be overloaded about 300 per cent. To properly protect the motor, it will be necessary to install a double-throw switch, with two sets of fuses, using a 15-ampere fuse in the running side and a 30-ampere fuse in the starting side. What you have experienced with this motor is not uncommon with motors that are protected by fuses that are of sufficient capacity to take care of the starting current.

Steam from a Cubic Foot of Water—How much steam would be made from one cubic foot of water at 62 deg. F.? R. G. D.

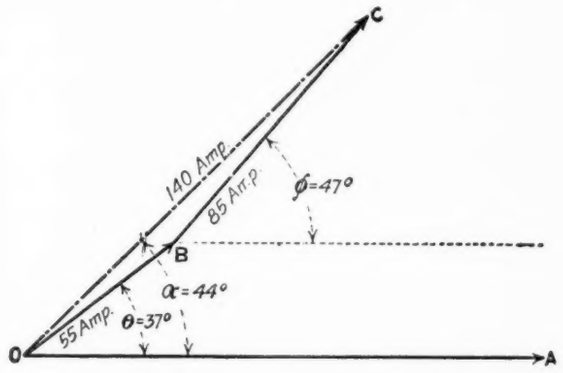
One cubic foot of water at 62 deg. F. weighs 62.355 lb., and the volume occupied by each pound, when converted into dry saturated steam, would depend on the pressure. At atmospheric pressure one pound of the steam would occupy a volume of 26.79 cu.ft. and the volume occupied by the original cubic foot of water converted into the same weight of steam would be $62.355 \times 26.79 = 1{,}670.5$ cu.ft. At the pressure of 10 lb. gage the volume of one pound of steam is about 16.3 cu.ft. and at that pressure the cubic foot of water would make $62.355 \times 16.3 = 1{,}016.4$ cu.ft. of steam. At the pressure of 50 lb. gage the volume of one pound of steam is about 6.65 cu.ft. per pound and the original cubic foot of water would make about $62.355 \times 6.65 = 414.7$ cu.ft.; while at a pressure of 100 lb. gage steam has a volume of 3.88 cu.ft. per pound and the steam generated from 62.355 lb. of water would occupy a space of 62.355×3.88, or only about 242 cubic feet.

Equality of Metering Gas at Different Pressures—Our natural gas service must be metered and delivered to our 4-in. gas line at 9 lb. pressure, so that we may obtain 3 lb. pressure which is necessary at our point of distribution. On account of the pressure at which the gas is metered, we pay for the meter registration multiplied by 1.59. What is our loss due to the required drop in line pressure? Would it not be advantageous to have a larger gas line to decrease the drop? W. H.

It is true that for delivery of the same weight of gas per hour there would be less drop of pressure in a larger gas line, and if the metering is performed with gas at a lower pressure, a smaller multiplier should be used. But gas metered at less pressure would have less density and, in order to pass the same weight of gas, a larger volume would be metered. If the meter is correct in registration of volume and the proper multiplier is used for conversion of the volume at any metered pressure to volume at standard pressure for rating the meter charges, the resulting charge would be the same for your use of the same weight of gas or for the same volume of gas discharged at the same pressure at the point of distribution. That is, there is no loss due to drop in the line pressure and from the use of a larger pipe there would be no reduction of charge for consumption of the same amount of gas.

Combined Power Factor—Two induction motors are supplied from the same source. One of the machines takes 55 amperes and operates at a power factor of 0.80 lagging, and the other has a power factor of 0.68 lagging when taking 85 amperes from the line. How is the power factor of the combined loads determined? M. A.

One of the easiest ways of determining the power factor of a load made up of two or more loads of known power factors is by a vector diagram and measuring, with a protractor, the phase angle of the resultant current to the



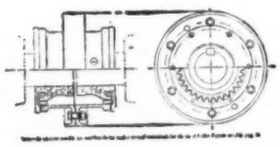
voltage. The natural cosine of this angle will be the power factor of the combined load. In this problem the 55-ampere load has a power factor of 0.80, which corresponds to the cosine of an angle of 37 deg.; consequently, *OB*, in the figure, which represents the 55-ampere load, is drawn at an angle of 37 deg. to *OA*, which represents the voltage. The power factor of the 85-ampere load is 0.68, which corresponds to the cosine of an angle of 47 deg. Then *BC* is drawn to scale, to represent 85 amperes, at an angle of 47 deg. to *OA*. The line connecting *OC* will represent to scale the combined current taken by the two motors, or in this case, is approximately 140 amperes, and the cosine of the angle *OC* makes with *OA* is the power factor. In this problem the angle is approximately 44 deg., the cosine of which is 0.72—the power factor of the combined load.

[Correspondents should sign their communications with full names and post office addresses.—Editor.]

Condensed-Clipping Index of Equipment

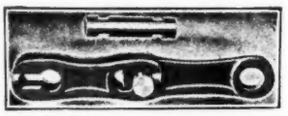
Clip, paste on 3 x 5-in. cards and file as desired

Coupling, Fast Flexible Turbo.
Bartlett Haywood Co., Baltimore, Md.
"Power."



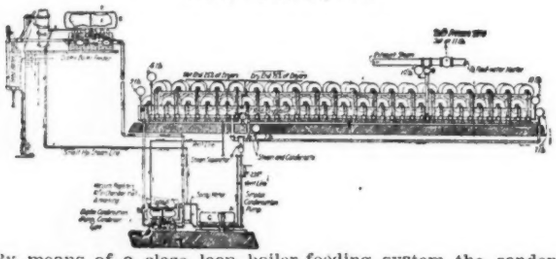
This coupling consists of two hubs, each keyed to its respective shaft. Each hub has an external spur gear cut on it at its maximum distance from the shaft end. Surrounding these hubs is a sleeve that is split in the center and bolted together by means of flanges. Each of these half-sleeves has an internal spur gear cut on its bore at the end of its flange. These gears engage the internal hub gears. A supporting ring is bolted to each half-sleeve on the face of the opposite flange. A slight clearance between the external and the internal gear permits of a certain amount of error of alignment between the two shafts. The coupling is filled with oil and when the coupling revolves the gear faces are submerged in oil.

Chain, Barlock Rivetless.
Endicott Forging and Mfg. Co., Inc., Endicott, N. Y.
"Power."



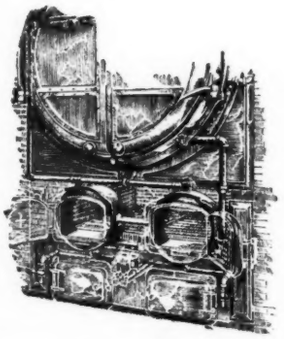
A solid-bar type detachable chain is comprised of interchangeable links and pins which are easily connected or detached at any angle without tools; the pins are reversible for double wear and have large bearing diameter. The chain consists of three parts —outside links, inside links and reversible pins. The outside links are locked to the pin. The locking links are made with a keyhole form of slots and are provided at their outer ends with risers which protect the locking shoulders. The outside links carry flight and bucket attachment. The center link is solid.

Boiler-Feeding System for Paper Mills.
Farnsworth Co., Conshohocken, Pa.
"Power," Feb. 17, 1920.



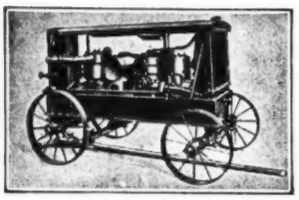
By means of a close loop boiler-feeding system the condensation from paper machines and other feeding apparatus together with makeup water is held under pressure and returned to the boiler at a high temperature. On the end of a return header for the wet-end drier, there is a duplex condenser-vacuum pump, having cold-water sprays for condensing the vapors in the return line, producing a forced steam circulation. The condensate is forced into a duplex boiler feeder and from there it goes to the boiler.

Protector, Smith Door.
International Engineering Works, Inc., Framingham, Mass.
"Power," Feb. 24, 1920.



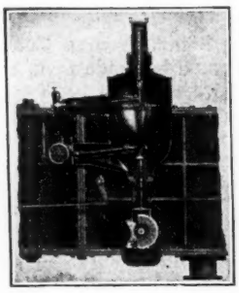
This door protector is designed to eliminate the frequent repairs by keeping the front door closed and can be attached to the ordinary hand-fired boiler fitting. The protector is made of fire-box steel with two connections to the boiler for direct and constant circulation of water through the protector and back to the boiler. The lower section is below the grate level, and a dead-plate is set in the protector at the grate line. The bottom of each protector is piped with a blowout. Foreign matter settles in a sediment chamber and is easily blown out. The protectors are made to fit door openings of boiler front for which they are to be used. Inside section is rolled up and flanged out against the outside shell, and the two are welded together.

Compressor, Portable Air
Ingersoll-Rand Co., 11 Broadway, New York City.
"Power," Nov. 25, Dec. 2-9, 1919.



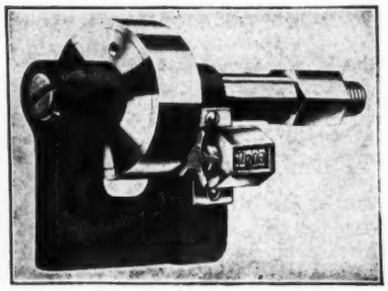
This outfit is all steel, the power plant consisting of a duplex vertical high-speed compressor driven by a four-cylinder four-cycle gasoline motor. It is built in two sizes—210 cu.ft. and 118 cu.ft. capacity—weighing 6,000 lb. and 4,000 lb. respectively. Compressor cylinders are cast enbloc with cylinder heads, valve chambers and water jackets integral. Both intake and discharge valves are of the plate type; all parts are lubricated by splash from an oil reservoir in the crank case. The compressor is provided with an inlet unloading device, and both compressor and motor are water-cooled.

Meter, Improved V-Notch Water.
Hoppes Manufacturing Co., Springfield, O.
"Power."



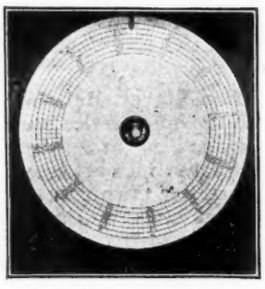
In order to insure proper recording and integrating, the water in the vessel, which is attached to the side of the tank, must always be in equilibrium with the water in the tank. As the vessel has an upward and downward movement, the connection between the vessel and the tank must be flexible. The improvement is a flexible connection between the vessel and the tank which consists of a brass tube with a "sylphon" connection on each end. This makes a mechanically flexible connection.

Recorder, Dwight Motion
Dwight Manufacturing Co., 12 South Jefferson St., Chicago, Ill.
"Power," Nov. 25, Dec. 2-9, 1919.



This device records the travel of elevators, mine hoists or the movement of any machine having a rotary motion. It consists of an annular ring mounted on the shaft, two end disks and a counter, operated by a pin at the periphery of the ring. The inner disk is attached to the shaft and rotates with it, imparting its motion to the annular ring by means of a ball clutch between the disk and the inner surface of the ring. To obviate the difficulty of the disk going back to zero as the elevator car goes up and down, a ball clutch is provided which prevents the ring from rotating in the reverse direction, thus causing the drum revolution to be in one direction only

Gage, Forseille Liquid Level.
L. F. Forseille, Union Gas and Electric Co., Cincinnati, Ohio.
"Power," Feb. 3, 1920.



This device indicates the true level of water, oil or other liquids that are subject to variable stages or tidal changes. A float operates in a pipe that is submerged in the liquid, and by means of a cord revolves a dial with the rising or lowering of the liquid. Spiral graduations are on the front of the dial, and a spiral indicator guide is on the back, both having the same pitch. As the disk revolves, the small roller supporting the radial moving indicator keeps the point of the indicator directly over the top of the figures denoting the water level at all points within its range.

Patented Aug. 20, 1918

Balancing Fuel, Lubricant and Motor*

BY WILLIAM F. PARISH

Dilution of motor-lubricating oil caused by the gasoline mixture escaping past the piston rings and by drainage of the diluted oil from the cylinder walls has always existed, but not until the period of high-end-point gasoline during the last three or four years has fuel loss become apparent. This condition has resulted in undue wear of engine parts and has affected the use of fuel, lubricant and power. A method of application of motor oils to correct some of present faults is suggested, although the true solution is better engine design.

DURING 1911, in conducting research work in connection with the use of various fuels and lubricants on a four-cylinder automotive engine and in examining the lubricating oils before and after use, it was noticed that the oil drawn from the crank case after use had undergone a considerable physical change, the most noticeable being that the viscosity of the oil had been lowered during use until it was only one-half or one-quarter as much as the viscosity of the new oil. The flash or ignition point of the used oil was only a third of the original, in some cases being lowered from 470 to 150 deg. F. Other just as remarkable changes had taken place in the gravity and cold test of the oil.

An article prepared by the author and published in June, 1912, ascribed the changed condition of the motor lubricant entirely to the leakage of gasoline vapor during the compression stroke, recondensation of this vapor in the crank case, absorption by the lubricant, and to a probable slight leakage down the walls of the cylinder, of unconsumed heavy portions of the fuel which had mingled with the lubricant, producing a similar effect. This has been a condition that has always existed, but has become more pronounced and better understood during the last two years.

The tremendous growth of the automotive industry during the past few years, with the consequent burden placed upon the oil industry of producing the vast amount of fuel required, has brought about an unbalanced condition. Because of the enormous increase in consumption of gasoline—from 15,000,000 bbl. in 1910 to approximately 95,000,000 bbl. in 1919—the petroleum industry has been able to meet demands only by the manufacture of a less volatile fuel.

There is no reason to believe that this pressure will diminish, but on the contrary there is ample evidence to show that it will continue to increase. It follows, therefore, that gas-engines must be so designed as to successfully consume this product. Navy Department specifications show that during the last few years automotive fuels have been gradually getting heavier, approximately from 360 deg. F. end point in 1916 to 428 deg. F. end point in 1919. The end point is the temperature at which the final part of the fuel vaporizes.

Practical Laboratory Tests

During the war it was necessary, before writing specifications for lubricating oils and fuels for aëronautic and other internal-combustion engines, to make a complete study of this subject in order that the fuel and lubricants could be so balanced that their combination in the engine would give the necessary lubricating results. These main tests resulted in the specification for Liberty Aëro oil, and had much to do with specifications for aviation gasolines. A four-cylinder, 100-hp. aëronautic engine was used for the special fuel tests of the series. It was operated under ideal test conditions, working with the same lubricant but with different fuels. Two of these fuels were especially made for the test and were distilled from the same crude. The first fuel tested was made after the German specifications for aviation gasoline, and had a gravity of 75.2 deg. Bé., with initial boiling point of 110 deg. F. and a final boiling point of 230 deg. F. The second fuel tested was made after the French specifications and had a gravity of 63.6 deg. Bé., and an initial boiling point of 140 deg. F., with a final boiling point of 292 deg. F. The third fuel was regular Navy specification motor-boat fuel under contract for the year 1917, and had a gravity of 61.3 deg. Bé., with an initial boiling point of 135 deg. F., and a final boiling point of 385 deg. F. To the last fuel a so-called gasoline energizer was added, which produced a fuel which, while it had an initial boiling point of 135 deg. F., had an end point of 422 deg. F., which in its last distillation range would be equivalent to the present-day commercial gasoline.

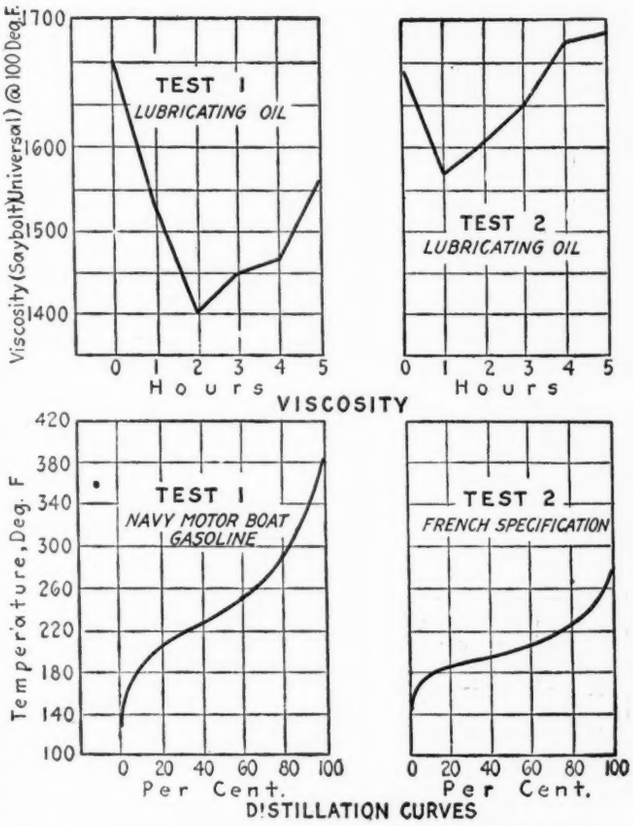


FIG. 1. GASOLINE DISTILLATION AND VISCOSITY CURVES OF LUBRICATING OIL TAKEN FROM ENGINE

The method of conducting the test was to run the engine continuously for five hours under test conditions, every observation in connection with the operation being recorded. At the end of every hour samples of lubricating oil were drained from the lubrication system of the engine and the same amount of new oil replaced. These samples were examined by an efficient corps of oil chemists. The effect of the four different classes of fuel upon the same lubricant is clearly registered in Figs. 1 and 2. The lightest or most volatile fuel shown in test No. 3 caused a lowering of the viscosity of the lubricating oil during the first hour of 30 seconds viscosity (Saybolt Universal Viscosimeter). The oil, however, recovered its body, and at the end of the fifth hour was 44 seconds above its original viscosity or body.

In test No. 2, with a slightly heavier fuel, there was a reduction in the body of the oil of 46 seconds during the first hour. The oil, however, after the first hour recovered

*Abstract of paper presented before Chicago section of the American Society of Mechanical Engineers, Jan. 23, 1920.

and had a viscosity of 28 seconds above its original body at the end of the fifth hour.

Test No. 1 with a semi-commercial fuel, showed a drop in the body of the oil in two hours of 150 seconds, with a slight recovery during the balance of the test. There was a total reduction of 16 seconds at the end of five hours from the body of the original oil.

In test No. 4 with the high-end-point gasoline, there was a drop in two hours of 142 seconds in the body of the lubricant, only a slight recovery and a total drop at the end of five hours of 108 seconds from the original body of the oil.

The sample taken at the end of the five-hour period of each one of these tests was tested in a distillation flask and the amount of heavy end of the gasoline recovered varied from 0.5 to 1.2 per cent, as indicated on Fig. 3. All the physical characteristics of the oil, such as gravity, flash, fire, viscosity, pour test, acidity and carbon content, showed a considerable change, as indicated in Fig. 4.

The results of the tests indicate quite clearly that dilution exists with even the most volatile fuel, but only during certain periods of the operation of the engine and under certain fixed conditions. With the lightest volatile fuel, which would also be the case with the engine operating on producer, natural or furnace gas, the tendency of the lubricating oil would be to build up in body, the same as in

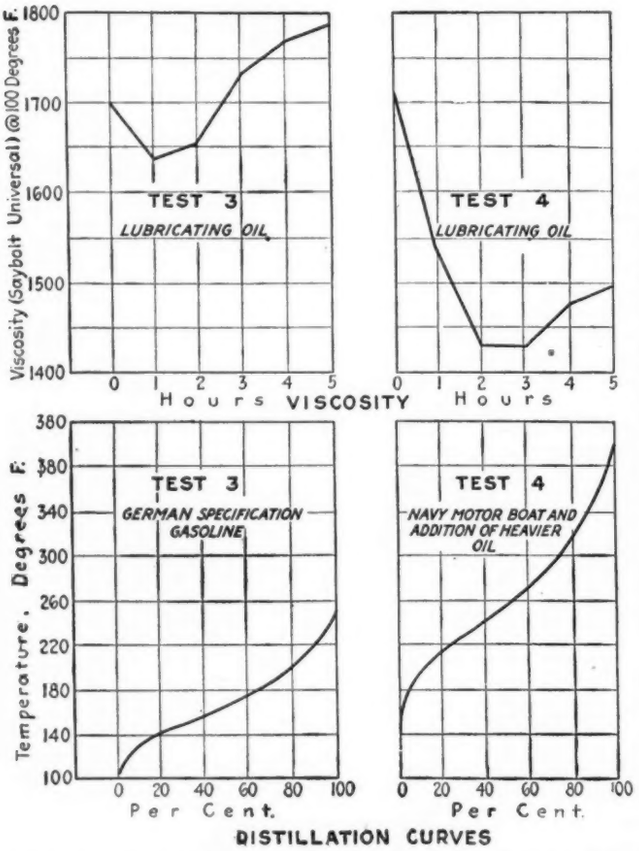


FIG. 2. DISTILLATION AND VISCOSITY CURVES WHEN USING GERMAN SPECIFICATION AND NAVY GASOLINE

any other class of lubrication work where the lubricant does not come in contact with lighter hydrocarbons or lighter volatile products that can be combined with it. The tests also indicated quite clearly that the heavier the end point of the fuel the greater is the effect of dilution, also the more permanent is its character.

In the foregoing experiments, it must be borne in mind that the aëronautic engine was operated with an exceedingly heavy lubricating oil, such as these engines require, and that carburetor and magneto adjustments were attended to by experts; that the engine was placed in perfect condition for the test and operated continuously without stopping, at high speed, for the entire five hours of the test.

Tests on Trucks

Other interesting data were secured from the examination of lubrication conditions of a considerable number of cars and trucks using commercial gasoline and lubricants. The cars, in some cases, were new as received from the manufacturer, and in other cases old, and old repaired.

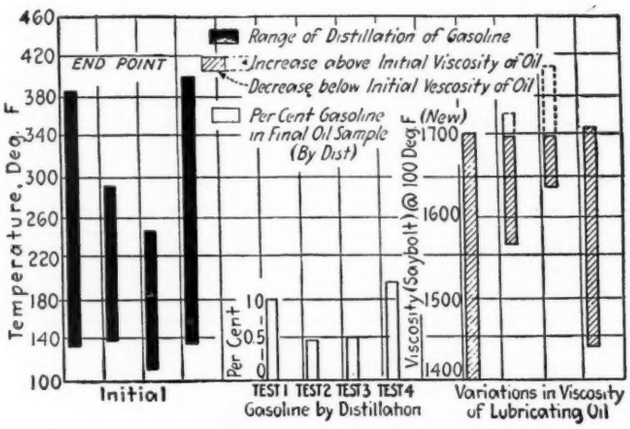


FIG. 3. RESULTS FROM SAMPLES OF OIL TAKEN DURING TESTS

The method of conducting the test was first to thoroughly clean the motor, then fill the crank case with the oil to be tested. The oils so used covered a range of commercial medium and heavy grades as indicated by Government specifications for motor oils. The cars were then allowed to operate in their regular business for periods of ten days during which time no particular care was given them other than ordinarily given commercial vehicles, but at the end of each two-day period an eight-ounce sample would be drawn from each crank case and eight ounces of the same oil used on that particular motor would be put in with whatever additional oil was necessary. The samples were examined for dilution by measuring all the product that could be distilled from the sample of oil under 500 deg. F. The viscosity of the sample before removal of the diluent was taken on a Saybolt Universal Viscosimeter at 100 deg. F. The method of making the ash test was to test the oil first in the Conradson carbon apparatus. After the carbon was determined, a gas flame was used for burning the carbon out of the dish. The ash that remained was then weighed and percentage taken of the whole sample. This ash was made up of iron, iron oxide and silica.

In a 3½-ton new truck the viscosity at the end of ten days was reduced from 345 to 100 seconds. Dilution on the tenth day amounted to 19 per cent and ash, 1.62 per cent.

In a 5-ton truck that had run 5,205 miles, but completely overhauled, the viscosity dropped from 358 to 90 seconds during the first six days, then recovered to 184 seconds at the end of ten days. Dilution in the case of this truck seemed to be dependent upon weather conditions; at the end of the six-day period there was 20.6 per cent of dilution, which was reduced to 8 per cent at the end of the ten-day period.

In a 3½-ton overhauled truck that had been run 12,551 miles the viscosity held practically constant for the first two days when the truck was not operating in the open. After the second day there was a drop in viscosity to 43 seconds. Dilution at the end of the tenth day was 26.5 per cent.

The Cause of Dilution

With the present-day fuel and the present-day automotive engine, all lubricants change considerably in body within a very short operating period, this new body being the result of dilution and the dilution coming from the heavy end of the fuel.

The amount of dilution is to a great extent influenced

by the temperature of the surrounding air, the reason being that the colder the engine and oil in the engine the greater will be the amount of fuel it will absorb and hold. Conversely, the hotter the air or lubricating oil in the engine the less will be the amount of fuel held in dilution, as all the fuel can be distilled off at high temperature.

To see if any of the dilution of a motor oil could be caused by decomposition or cracking of the oil by being thrown against hot surfaces, tests were made by the author with a commercial car operated by pure benzol. Percentages of 4 to 8 per cent of benzol were distilled from the motor oil after 100-mile runs. The oil, after the benzol had been removed, possessed all its original characteristics. These benzol tests determined satisfactorily that dilution was being caused by the fuel, though the burned odor of the oil did indicate some degree of decomposition.

The conclusions drawn from the foregoing test with benzol are confirmed by the results of a test on a Nash six-cylinder engine operated for ten hours with city gas. The original viscosity of the oil at 100 deg. F. was 205 seconds; after ten hours' operation the viscosity had increased to 255 seconds, the flash and fire points remaining practically the same, showing that there had been no change in the oil caused by cracking and reabsorption of the lighter products, but that the absence of lighter products allowed the oil to become heavier in body.

Dilution is caused mainly by leakages past the piston rings during the compression stroke. There is a secondary leakage, caused during the suction stroke, where there is a partial separation of heavy ends of the fuel from the gas entering the cylinder and absorption by the film of oil on the cylinder walls, causing some drainage on the lower exposed surfaces during the compression stroke. It is doubtful if any drainage or leakage takes place during the exhaust stroke or during the power stroke.

Leakage of the gasoline or gasoline mixture is influenced by the following mechanical or operation conditions: Piston clearance, richness of mixture, improper ignition, operating temperature of motor affected by weather, body of lubricant or thickness of film on walls of cylinders, condition of cylinder walls, condition of piston rings as affecting their all-around fit in the grooves and against the cylinder walls, intermittent operation, priming and using the choker when engine is cold in starting, choking when overloading, character of fuel, carburetor out of adjustment, vacuum system out of adjustment.

Losses caused by dilution are of four kinds; namely, the loss of fuel, loss of power, wear of all parts and loss of lubricant. Loss of fuel is not entirely due to the heavy end of the fuel or to the present heavy character of the fuel, as, irrespective of the nature of the fuel, whether light and volatile or heavy, there will be a fuel loss during the compression stroke in a four-stroke cycle engine. In the case of heavy end fuel this loss is reflected to a magnified extent in the dilution effect upon the lubricating oil. In the case of a much lighter fuel, say one of 72 deg. Bé., the loss by the rings during the compression stroke would be just as pronounced in percentage of the amount taken into the cylinder, supposing the sealing effect of the lubricant on the piston rings to be always the same, but the effect would not be so noticeable, owing to the lubricant's inability to absorb and hold the lighter fuel as a diluent at operating temperatures.

The quantity of fuel lost in this manner is in no way represented by the amount of dilution found in motor oils, as there is a limited point of saturation of a motor oil dependent upon the condition under which it is operating. The losses that constantly occur are disposed of by the engine in some other way than by being entirely absorbed by the lubricant. The loss of fuel by leakage means that all the fuel placed in the cylinder is not converted into power.

Loss of and Through the Lubricant

The first effect of dilution is upon the viscosity or body of the lubricating oil, reducing this body to a point where it cannot be considered to be an efficient lubricant for a motor. This causes three conditions, which can be stated as loss of lubricant, loss of power and wear of the machine.

The first effect is the wastefulness of the lubricant, as the entire loss of lubricating oil in an internal-combustion engine is caused by the lubricant creeping up the cylinder walls, mainly during the first cycle or admission stroke, and being later consumed in the combustion chamber. The lighter the oil is in body the greater will be this loss.

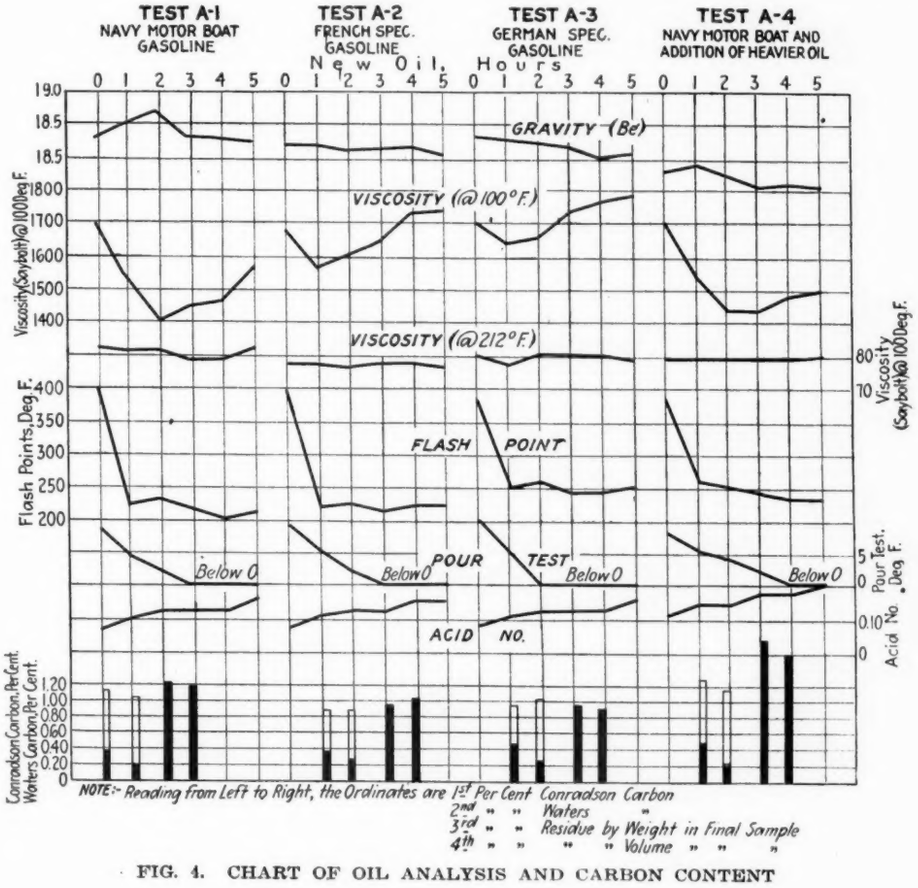

TEST A-1
NAVY MOTOR BOAT GASOLINE
TEST A-2
FRENCH SPEC. GASOLINE
TEST A-3
GERMAN SPEC. GASOLINE
TEST A-4
NAVY MOTOR BOAT AND ADDITION OF HEAVIER OIL
New Oil, Hours
GRAVITY (Be)
VISCOSITY (@ 100° F.)
VISCOSITY (@ 212° F.)
FLASH POINT
POUR TEST
ACID NO.
Below 0
Viscosity (Saybolt) @ 100 deg. F.
Flash Points, Deg. F.
Pour Test, Deg. F.
Acid No.
Conradson Carbon, Per Cent.
Waters Carbon, Per Cent.
NOTE:- Reading from Left to Right, the Ordinates are 1st Per Cent Conradson Carbon
2nd " " Waters "
3rd " " Residue by Weight in Final Sample
4th " " " Volume " " "

FIG. 4. CHART OF OIL ANALYSIS AND CARBON CONTENT

Further, there is another loss, which is due to the present condition of dilution and the attempts made to offset this, and that is by the removal of lubricating oil from the engine at periods of from 300 to 800 miles instead of the former periods of double this mileage, this mixture being thrown away.

The basic rule in lubrication is illustrated best by considering the power necessary to operate a machine composed of a number of bearings. If the machine is lubricated perfectly with oil of the proper viscosity, the power will be at a minimum and speed at a maximum, and there

should be practically no wear on the bearings. If, however, an oil of double or treble the viscosity is used as a lubricant, the power necessary to move the machine at the same speed will have to be materially increased due entirely to the fluid friction of the lubricant itself. Under this condition there will be practically no wear, as the surfaces will be kept well apart. Attempting to lubricate the same machine with an oil that is entirely too light or thin for the work will also require the development of practically as much or even more power than in the case of the extra-heavy oil, the resistance being due to metallic or solid friction, one of the results of which is, of course, abrasion with constant changing of the surfaces.

A lubricant actually working in a motor should have a body equal at least to that possessed by a new heavy spindle oil (130 seconds viscosity at 100 deg. F.), and an oil of such light body must be used in a forced-feed system where the pressure and constant flow of the oil will make up for its lack of thickness of lubricating film.

As a matter of fact, under present conditions of operation, most motor oils when in an engine, in the winter especially, are much lighter than a lubrication engineer would ever think of applying to the lightest piece of machinery he would be called upon to lubricate, which is a light spindle in a textile mill. These spindles rotate about 10,000 r.p.m. and the side pull or pressure averages two pounds. The pressure on the bearing side will not be above ten pounds per square inch. The high rotation speed of the spindle tends to keep it away from the bearing surface and keep it in the center of the bolster. About one ounce of oil is placed in the base of the spindle and this amount is added to every 15 to 45 days. It has been proved by the most careful experiments that oil that has a viscosity of less than 60 seconds at 100 deg. F., Saybolt Universal, will allow these spindles to wear perceptibly in a month's time. The oil remaining in the spindle base will become black and contain a considerable proportion of iron and iron oxide. Further, the same spindles, when lubricated with oil of from 70 to 80 seconds viscosity, do not wear, owing to the fact that the oil is of sufficient body to keep the surfaces apart.

Therefore, the result of the lubrication of an automotive engine with a mixture of lubricating oil and heavy ends of the gasoline having a viscosity below that required for a textile spindle can only result in excessive wear, and this is shown by the ash remaining from the complete distillation of the sample of mixture taken from the motor.

Wear of Machine

The effect of poor lubrication is indicated to some extent by the readings of ash. These readings were taken on each sample and represent the total amount of ash in that particular sample. The ash is made up of oxide of iron, other metal, and of silica, the iron and other metal being from natural or unnatural wear of the engine, the oxide of iron coming from the water that has been in contact with the metal, and the silica coming from road dust, though at the time of the year this particular test was made the streets were well covered with snow and but little road dust could be expected to enter the engine through the carburetor or breather holes.

The wear of the machine is reflected in repair bills, in the necessity for reboring cylinders, refitting rings, when an engine becomes noisy and when compression is lost.

All these features are largely the result of wear caused by the present unbalanced condition of fuel, lubricant and engine.

It is necessary to reconsider the entire problem of the internal-combustion engine on the basis of present-day fuel and its effect upon the lubricant. There is but little more that the oil industry can do in regard to the fuel situation. Considerable can be done in regard to the application of motor oil; that is, the selection of motor oil for these engines upon some other basis than has generally been prevalent in the past whereby a motor of any one manufacturer was supposed to be properly suited by a certain grade of lubricant for its entire life irrespective of its physical condition. Modern lubrication engineering can, to a considerable extent, rectify some of the damage done by this old system of selecting lubricants, basing the selection upon more scientific or practical grounds, taking into consideration all the factors that surround the problem. The entire problem of lubricant, fuel and engine conservation can be solved only by the automotive engineer or designing mechanical engineer providing means and methods whereby the fuel will be entirely consumed on top of the pistons. Effecting compression of the air and gasoline outside of the cylinder and igniting the charge upon admission and during the power stroke would overcome practically the entire amount of fuel and air-mixture leakage that takes place during the compression stroke of the present four-cycle motor. Other methods will undoubtedly be proposed and worked out successfully as soon as the seriousness of the present situation is fully established.

Economizer Explosions

Failure to close dampers while the feed is open according to statistics taken from a recent report of the Board of Trade of the Manchester Steam Users' Association, England, has resulted in more economizer explosions than any other single condition.

The report shows that since 1882 seventeen serious economizer explosions have taken place in England. Of this number nine were destructive to surrounding property. It is claimed that four of the explosions were probably caused by neglecting to close the dampers while the feed was open; three were reported due to wear and tear and the remainder were accounted for in various ways. Many firemen do not know that it is necessary to close the damper when the feed is shut off, and even among those who have been warned there is a prevalent disregard of this precaution.

Failures of economizer pipes occur almost daily, says the report, the following explanation being offered for this large number of pipe failures compared to the small number of serious explosions: Under ordinary working conditions economizers are full of water which is cold at the bottom and hot at the top; if a pipe fails at the bottom, cold water runs out and the water level in the boiler sinks or water can be seen running out of the flue; and if a pipe fails in an economizer through which hot flue gases have been passing, while the feed supply has been shut off, the whole mass of water in the economizer will have been raised to a temperature equal to that of the water in the boiler, and as hot water under pressure contains about thirty times its volume of steam, it is evident that if one pipe of an economizer were to burst, the large volume of high-pressure steam suddenly liberated would cause an explosion. This might be prevented if the damper was closed each time the feed was shut off.

The effect of passing hot gases through an economizer when not in use is uncertain. The temperature of flue gases is about 600 deg. F., or approximately equal to that of superheated steam. Superheated steam can safely be passed through cast-iron pipes into the cast-iron cylinders of engines that are subject to reversals of stress, without failure occurring. It was a common practice in the early days of electric power, in order to increase boiler power, to shut off the feed during the peak-load period, while allowing the gases to pass through the economizers, converting them temporarily into steam producers. This increased the boiler power approximately 30 per cent.

Investigations of explosion of economizers have resulted in a number of interesting theories being advanced as to whether the side pressure suddenly liberated by the bursting of a pipe would be sufficient to fracture the other pipes. One assumption is that when a pipe accidentally explodes, the flying fragments would fracture at least some of the remaining pipes. Mathematicians by a number of experiments have shown that rods offer practically no resistance to pressure waves. An actual demonstration of this was given at the Silverton explosion, mentioned in the Manchester report, when all walls and buildings were destroyed and every one of the tall chimneys was left standing.

A simple experiment seems to settle the question about gas-flue explosions and at the same time furnishes proof

that it is entirely a matter of chance whether a pipe explosion will confine itself to one pipe or a sheet. A model economizer made of glass pipes was used in the test. It was estimated that the pipes should break under a side pressure of fourteen pounds per square inch. The central tubes were replaced by an air reservoir whose end was closed with a celluloid disk. When the pressure had reached about 300 lb., the disk burst with a loud report, but no pipes were broken. The test was repeated with broken pipe ends piled up over the celluloid, and this time some of the vertical pipes were broken. This indicated that side pressure alone without flying fragments will not injure the other pipes.

Water Power of British Columbia

Information of value to the whole western coast of America is contained in a report issued under the title of "Water Powers of British Columbia," by the Canadian Commission of Conservation. The report is a large volume, well illustrated, containing 650 pages and has taken a number of years to prepare. It is a complete compendium of data relating to the water-power resources of British Columbia. In round numbers, the horsepower totals derivable from the various estimates presented in the power-site tables for districts into which the province has conventionally been divided are as follows:

	24-hour hp.
I. Columbia River and tributaries (north of the international boundary)—This comprises the portion of the province lying between its eastern boundary and the water-shed of the Fraser River	610,000
II. Fraser River and tributaries—This includes practically the entire area of the great interior plateau	740,000
III. Vancouver island	270,000
IV. Mainland Pacific coast and adjacent islands (except Vancouver Island)—This includes all the rivers north of the Fraser which drain into the Pacific	630,000
V. Mackenzie River tributaries—(A rough estimate made for inclusion in this summary)	250,000
Grand total	2,500,000

Statements made show that there is about 500,000 horsepower that, at least for many years to come, can hardly be economically developed because interference with the fishing industry or the proximity of railways renders development impracticable. There are also some other qualifying statements applicable to portions of the power tables, but in round figures the grand total of estimated 24-hour horsepower, including an allowance for the entities mentioned, may be placed at about 3,000,000.

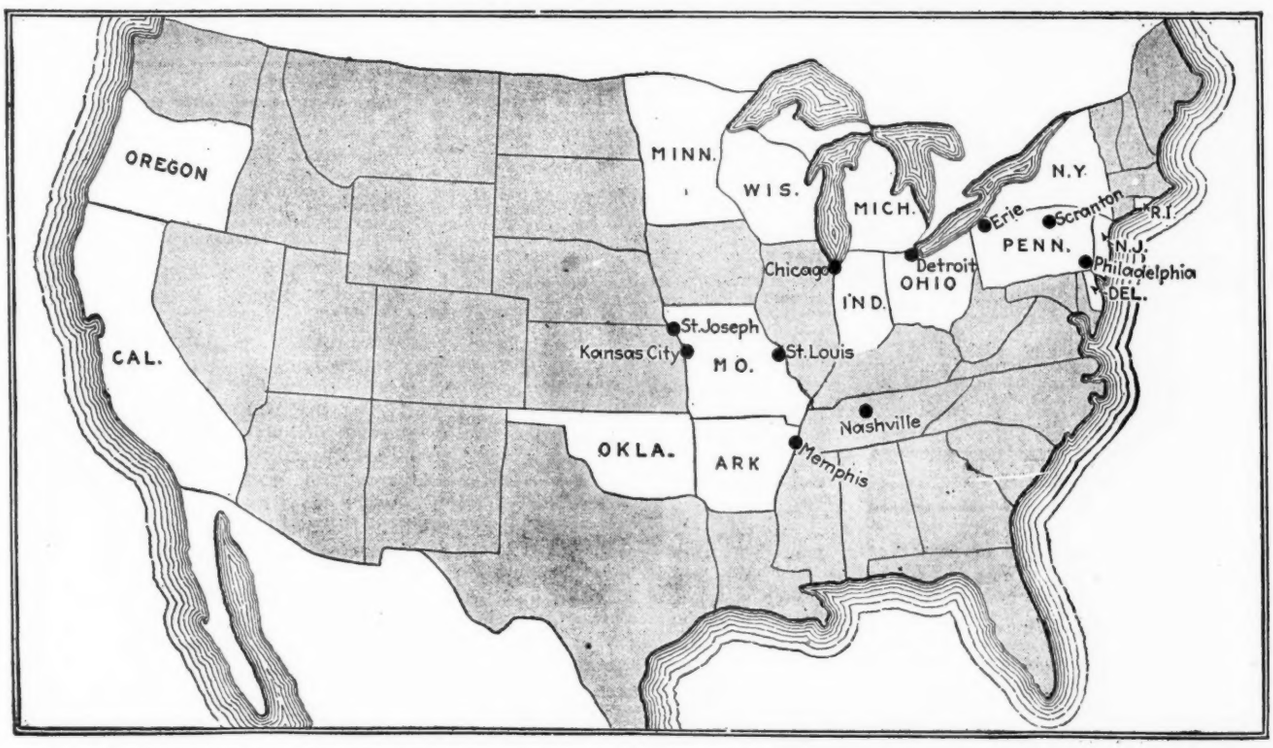
Frequently, in reports on water-power resources it has been the tendency to deal with power development exclusively without adequately considering such related subjects as domestic and municipal supply, agriculture and irrigation, navigation, fisheries and riparian rights. In this report the author, although dealing with water-power resources, has recognized that water power is but one of the important uses to which inland waters may be applied.

National Board of Boiler and Pressure Vessel Inspectors Organized

As a result of efforts of the members of the National Uniform Boiler Law Society, the National Board of Boiler and Pressure Vessel Inspectors was organized at the headquarters of the American Society of Mechanical Engineers, New York City. The purpose of the organization is to promote uniform boiler laws throughout the jurisdiction of the members; for the interchange of rulings, opinions and the approval of specific designs and devices used in connection with boilers and other vessels; for the uniform stamping of boilers and also for the examination of boiler inspectors.

The membership is restricted to officials charged with the enforcement of regulations covering boilers and other pressure vessels in states and cities that have adopted the Boiler Code formulated by the American Society of Mechanical Engineers.

Public utilities throughout the country consume annually about 35,000,000 tons of coal. This is taken from figures recently compiled and published by the Geological Survey, showing the amount of electricity produced in this country by central power stations and the fuels. The report of the Survey also shows that from 722,000 bbl. of petroleum and derivatives burned each month to generate power, the use of oil has increased to 1,276,000. In some states a small amount of natural gas is used to generate electric power. Last year the consumption per month throughout the country was about 1,800,000 cubic feet.



MAP SHOWING THE STATES (WHITE) AND CITIES THAT HAVE ADOPTED THE A. S. M. E. BOILER CODE

Dinner of the Boston Engineers

The eleventh annual dinner of the Boston Engineers was held on Tuesday evening, March 30, under the auspices of the American Institute of Electrical Engineers, the Boston Society of Civil Engineers and the American Society of Mechanical Engineers, the following societies participating: American Chemical Society, American Institute of Mining and Metallurgical Engineers, American Society of Civil Engineers, Engineers' Club, Illuminating Engineering Society, New England Water Works Association, Plant Engineers' Club, the American Society of Heating and Ventilating Engineers and the Boston Society of Architects.

The principal speakers and their subjects were: Paul D. Cravath, legal representative in Europe of the United States Treasury Department during the war, "Some Economic Aspects of the Treaty of Paris"; His Excellency, Calvin Coolidge, governor of the Commonwealth of Massachusetts; Hon. Andrew J. Peters, mayor of the City of Boston; Roscoe Pound, dean of Harvard Law School, "Social Engineering." Brief remarks were made by Robert Spurr Weston, vice-president, Boston S. C. E.; J. Parke Channing, chairman, Engineering Council; Arthur P. Davis, president, A. S. C. E.; Sidney J. Jennings, past-president, A. I. M. and M. E.; Fred J. Miller, president, A. S. M. E.; Calvert Townley, president, A. I. E. E.

The dinner this year was under the especial charge of the Electrical Engineers, and Irving E. Moultrop, representing that society, acted as chairman. Prof. Dugald C. Jackson was toastmaster. A resolution was passed inviting the local members of the American Institute of Mining and Metallurgical Engineers to co-operate in the arrangements for future dinners, completing the representation of the "four founder societies" in that function. The speeches were more than ordinarily good, and the attendance taxed the large auditorium of the Boston City Club.

New Publications

THE MECHANICAL WORLD YEAR BOOK FOR 1920. Published by Emmott & Co., Ltd., Manchester, England. 6 x 9 in.; 328 pages.

The present edition of this reference book has been further enlarged. Among the new features are a section on hydraulic work and another on Heating and Evaporating Liquids. A great deal of information and data are given in a small space and the selection of the material has been made with the idea of giving practical assistance in mechanical engineering practice. In addition to the various tables of squares, cubes, areas of circles, etc., which are always found in engineering handbooks, a large number of tables of engineering data and constants are included. The tables of the properties of steam are from values now considered obsolete, which materially detracts from the value of the book. As is natural, the majority of the data on standards are those of English practice rather than American, although a great deal of the material in the book applies equally well in either country.

SELLING YOUR SERVICES. By George Conover Pearson. Published by the Jordon-Goodwin Corporation, New York City. Cloth; 237 pages; 5 x 8 in. Price, $2.00.

This book treats in a practical way, by a number of lectures, methods of job-getting which the author has put into actual practice with success. The main idea of the edition is that the application of salesmanship and advertisement to the problem of getting the position for which a man is most suited is much more likely of results than the customary hit-or-miss method. It gives in concrete form, systematic methods of self analysis in order to properly locate the field of usefulness for which a man is best fitted and also gives a complete and comprehensive description of obstacles which must be overcome and the methods for doing so. This covers competition, selling your usefulness, the purpose of long and short letters of application and suggestions on writing them, capitalizing experience, etc. The book concludes with an account of the value of a carefully planned campaign, the danger of overselling services and methods of investigation of prospective employers.

Personals

Paul R. Duffey, formerly supervisor of power plants of the Potomac District U. S. R. R. A., has been appointed chief inspector of motive power, Maintenance of Equipment Department, Western Maryland, R. R. Mr. Duffey will also be supervising officer of all power plants on the Western Maryland System and subsidiary lines.

Ernest H. Peabody, after thirty years of service with the Babcock & Wilcox Co., has resigned in order to assume charge of the Peabody Engineering Corp., of 160 Broadway, New York City. Mr. Peabody entered the employ of the Babcock & Wilcox Co. in 1891 and was with them continuously until the time of his resignation. He is a graduate of Stevens Institute of Technology, class of 1890, with the degree of mechanical engineer.

Frank Espey, formerly manager of the Atlantic City Electric Co., has been promoted to the position of general manager of the Ohio Power Co., of Canton, Ohio. Mr. Espey will be replaced by C. E. Terrey, for ten years manager of the East Liverpool plant. Mr. Terrey's post at East Liverpool will be filled by Harry C. Sterling, who for more than five years has been assistant manager of the Atlantic City Electric Co's. plant.

Society Affairs

The American Society of Mechanical Engineers, Waterbury Branch, has planned a meeting for Apr. 7.

The American Society of Mechanical Engineers, New Orleans Section, will meet on Apr. 15. The prime object of the meeting will be a general discussion of section affairs.

The Engineering Council of the United Engineering Societies will hold a meeting in Washington, D. C., on Apr. 15. It is planned to hold one meeting each year in Washington.

The National Electric Light Association, Pacific Coast Section, has gained more than two thousand members since last November according to a report of the membership committee made Apr. 1.

The Hartford, Conn., Branch of the American Society of Mechanical Engineers will meet at the City Club, Hartford, Apr. 12. The subject to be presented at the meeting will be "Drop Forgings" and "Die Castings."

The Chicago Section of the A. S. M. E. will hold a joint meeting with the Western Societies of Engineers in April. Prof. B. W. Benedict, of the University of Illinois, will read a paper on "Teaching the Principles of Shop Management."

The Entertainment Committee of the National Electric Light Association convention, which is to be held at Pasadena, Cal., in May, have arranged so that delegates will receive invitations to attend the California Mission Play. The play will take place in a theater but a short distance from the Hotel Huntington, the headquarters of the gathering.

The Institute of Radio Engineers, of the College of the City of New York, will meet at the Engineering Societies Building, New York, on Apr. 7, at 8:15 o'clock. A paper on "The Reduction of Atmospheric Disturbances in Radio Reception," by Dr. Louis W. Austin, head of the United States Naval Radio Telegraphic Laboratory, Washington, D. C., will be presented.

Cornell Society of Engineers has called a meeting of Cornell graduates in engineering to be held on the evening of April 9, in the Engineering Societies Building, New York City. The meeting is called, partly with the idea of forming a general Cornell engineering society, now that the different engineering schools at Cornell are to be combined into one general engineering college. The new dean of the combined college, Prof. Dexter S. Kimball, will be one of the speakers.

The American Association of Engineers, Pittsburgh Chapter, has started a drive to bring the next annual convention to Pittsburgh. Delegates to the 1920 convention, which is to meet in St. Louis in May, will work in behalf of the movement. Another plan which the Pittsburgh chapter has under consideration is the effective cooperation of members of national, state and local societies so that members of any of the societies who are in good standing can join the Pittsburgh chapter of the A. A. E. for one-half the usual entrance fee.

The American Institute of Electrical Engineers will hold its annual meeting jointly with the American Electrochemical Society on Apr. 9 in Boston. A morning session will be held at the Plaza Hotel, the subject for the morning to be "Electricity Produced Alloys." In the afternoon a tour through the Lynn, Mass., works of the General Electric Co. will be made by members of both societies. The second session will be held during the evening, and a number of papers on "Power for Electrical Chemical Purposes" will be read.

Business Items

The Fitzgibbons Boiler Co. has removed its offices from 17 Battery Place to 1181 Broadway, New York City.

The Brown Instrument Co., of Philadelphia, is erecting two new buildings, one for the manufacture of recording therometers and the other to be used as a research department. The total cost of the new plants is estimated at $100,000.

The Barber-Greene Co., of Aurora, Ill., has completed the organization of branch offices at St. Louis, R. E. Faulke, manager; Pittsburgh, J. A. Gourney, manager; Philadelphia, F. S. Sawyer, manager; and Indianapolis, W. T. McDonald, manager.

The Metal & Thermit Corp., New York City, N. Y., has appointed James G. McCarthy, manager of its Canadian branch, with headquarters in Toronto, and has transferred Robert L. Browne from the New York Office to Boston. Mr. Browne is to have charge of sales in New England States.

The General Electric Co., has completed negotiations to lease, with the option to buy, the forty-acre war plant of the Remington Arms Co., at Bridgeport, Conn. The buildings, which are of the latest type construction, cover about 900,000 sq.ft. and the floor area is over 1,555,257 sq.ft. The deal involves about $7,000,000.

The Dallas Power and Light Co., of Texas, at a meeting of the directors, elected the following officers: J. F. Strickland, president; Harry L. Seay, W. B. Head, C. E. Calder and Charles W. Davis, vice presidents; J. B. Walker, secretary and treasurer; C. E. McBride, C. L. Cox and J. C. Thompson, assistants to the secretary and treasurer.

THE COAL MARKET

BOSTON—Current prices per gross ton f.o.b. New York loading ports:

Anthracite

	Company Coal
Egg	$8.20@$8.65
Stove	8.45@ 9.05
Chestnut	8.55@ 9.05
Pea	7.05@ 7.40
Buckwheat	3.60@ 3.80
Rice	2.30@ 2.50
Barley	1.25

Bituminous

	Clearfields	Cambrias and Somersets
F.o.b. mines, net tons	$2.85@$3.35	$3.15@$3.60
F.o.b. Philadelphia, gross tons	5.05@ 5.60	5.35@ 5.90
F.o.b. New York, gross tons	5.40@ 5.95	5.75@ 6.25
Alongside Boston (water coal), gross tons	7.00@ 7.75	7.60@ 8.00

Pocahontas and New River are practically off the market for coastwise shipment, but are quoted at $6.25@$7.00.

NEW YORK—Current quotations, White Ash, per gross tons, f.o.b. Tidewater, at the lower ports are as follows:

Anthracite

	Company Coal
Broken	$7.80@$8.25
Egg	8.20@ 8.65
Stove	8.45@ 9.05
Chestnut	8.55@ 9.05
Pea	7.05@ 7.40
Buckwheat	5.15
Rice	4.50
Barley	4.85
Boiler	4.85

Bituminous

Government prices at mines:	Spot
South Fork (best)	$3.25@$3.50
Cambria (best)	3.00@ 3.25
Cambria (ordinary)	2.60@ 2.90
Clearfield (best)	3.00@ 3.25
Clearfield (ordinary)	2.60@ 2.90
Reynoldsville	2.85@ 2.90
Quemahoning	3.25@ 3.50
Somerset (medium)	3.00@ 3.25
Somerset (poor)	2.50@ 2.75
Western Maryland	2.50@ 2.75
Fairmont	2.25@ 2.50
Latrobe	2.60@ 2.90
Greensburg	2.75@ 3.00
Westmoreland ¾ in.	3.40@ 3.50
Westmoreland run-of-mine	2.75@ 3.00

PHILADELPHIA—Bituminous coal prices vary according to district from which they are mined. For ordinary slack the price is $2.45@$2.55; lump, $3.35, at the mines.

BUFFALO—

Anthracite

	On Cars, Gross Ton	At Curb, Net Ton
Grate	$8.55	$10.80
Egg	8.80	10.65
Stove	9.00	10.85
Chestnut	9.10	10.85
Pea	7.75	9.30
Buckwheat	5.70	7.75

Bituminous

Allegheny Valley	$4.80
Pittsburgh	4.65
No. 8 Lump	4.65
Mine-run	4.80
Slack	4.10
Smokeless	4.60
Pennsylvania Smithing	5.70

CLEVELAND—Prices of coal per net ton delivered in Cleveland are:

Anthracite

Egg	$12.25@$12.40
Chestnut	12.50@ 12.70
Grate	12.25@ 12.40
Stove	12.40@ 12.60

Pocahontas

Nine-run	$7.50

Domestic Bituminous

West Virginia split	$8.50
No. 8 Pittsburgh	$6.60@ 6.90
Massillon lump	8.25@ 8.50
Coshocton lump	7.15

Steam Coal

No. 6 slack	$5.25@$5.50
No. 8 slack	5.10@ 5.50
Youghiogheny slack	5.25@ 5.50
No. 8 ¾ in.	5.70@ 6.60
No. 6 mine-run	5.25@ 5.50
No. 8 mine-run	5.75

Only coal available is mine-run Pocahontas.

MIDDLE WEST—Chicago quotations, f. o. b. cars at mine:

	Springfield, Carterville, Williamson, Franklin, Saline, Harrisburg	Fulton, Peoria	Grundy, La Salle, Bureau, Will
Lump	$2.55@$2.70	$2.95@$3.10	$3.25@$3.40
Washed	2.75@ 2.90		3.45@ 3.60
Mine-run	2.35@ 2.50	2.75@ 2.90	3.00@ 3.15
Screen'gs	2.05@ 2.20	2.35@ 2.50	2.75@ 2.90

New Construction

PROPOSED WORK

Me., Clark Mills (Hollis Center P. O.)—The Clark Power House Co. is having plans prepared for the construction of a 1 story power house. Sawyer & Bean, 11 Lisbon St., Lewiston, Engrs.

Conn., Ansonia—The Ansonia O. & C. Co., 153 Main St., plans to construct a 1 story power house.

N. Y., Albany—Charles F. Rattigan, Supt. of Prisons, Capitol, Albany, received bids for furnishing labor and material for the heating work at Sing Sing Prison, Ossining, from A. B. Barr & Co., 6 River St., Yonkers, $92,936; John W. Danforth Co., 70 Ellicott Sq., Buffalo, $96,900; W. B. Armstrong Co., 3 Fulton St., Albany, $98,000. Noted March 3.

N. Y., Black River—The St. Regis Paper Co. is preparing plans for the construction of a power house and hydro-electric development of the Black River to furnish 9,000 hp. F. L. Carlisle, Watertown, Pres.

N. Y., Brooklyn—Levy Bros., c/o Bedford Theatre, Bedford Ave., are having plans prepared for the construction of a theatre on New Utrecht Ave. and 51st St. A steam heating system will be installed in same. Total estimated cost, $250,000. T. W. Lamb, 644 8th Ave., New York City, Archt. and Engr.

N. Y., Brooklyn—E. Riegelmann, Boro Pres., rejected bids for furnishing, delivering and installing 1 steam engine. Estimated cost, $12,000. Work will be readvertised.

N. Y., Flushing—Wilmer & Vincent, 1451 B'way, New York City, are having plans prepared for the construction of a 1 story theatre and store building. A steam heating system will be installed in same. Total estimated cost, $300,000. E. C. Horn & Son, 1476 B'way, New York City, Archts. and Engrs.

N. Y., New York—F. B. Jennings, c/o S. N. Polis, Archt. and Engr., 50 Church St., is having plans prepared for the construction of a 16 story office building at 7-11 Water St. A steam heating system will be installed in same.

N. Y., New York—The New York Edison Co., Irving Pl. and 15th St., plans to construct a 113 x 177 ft. transformer station on Inwood Ave. A steam heating system will be installed in same. Total estimated cost, $100,000. W. Whitehill, 32 Union Sq., Archt. and Engr.

N. Y., New York—The West 48th St. Realty Co., c/o Gronenberg & Leuchtag, Archts. and Engrs., 303 5th Ave., is having plans prepared for the construction of a 14 story hotel on 8th Ave. and 43rd St. A steam heating system will be installed in same. Total estimated cost, $1,500,000. H. Claman, Pres.

N. Y., Ogdensburg—The Bd. of Pub. Wks. will receive bids for the installation of a 50 hp. electric motor and air compressor for use at the city crushing plant. Total estimated cost, $1,500.

N. Y., Old Forge—The Special Committee plans to build a municipal lighting and water supply plant. Estimated cost between $150,000 and $200,000. Address Maurice Callahan, 1st Natl. Bank, Pres.

N. J., East Orange—Edward V. Warren, Archt., Essex Bldg., Newark, is preparing plans for the construction of a 5 story, 70 x 140 ft. hotel on Harrison St. A steam heating system will be installed in same. Total estimated cost, $500,000. Owner's name withheld.

N. J., Jersey City—The City Comn. will receive bids for the construction of a power house for the Jersey City Hospital Building. Mechanical equipment will be installed in same. Total estimated cost, $50,000.

N. J., Newark—The Bd. Educ., Essex Bldg., received bids for installing a steam heating system in the proposed 3 story, 70 x 86 ft. Franklin School addition, from John H. Cooney, 210 North 4th St., $38,467; Jachnig & Peoples, 221 13th Ave., $43,467.

N. J., Newark—The Newark Athletic Club, 207 Market St., is having plans prepared for the construction of a club nouse at 16-18 Park Pl. A steam heating system will be installed in same. Total estimated cost, $500,000. Jordan Green, 27 Clinton Ave., Archt.

N. J., South Orange (Orange P. O.)—Henry Rosensohn, Archt., 188 Market St., will receive bids for the construction of a 3 story, 75 x 150 ft. theatre and office building on South Orange Ave. and Scotland Rd., for the South Orange Theatre Co., 929 Broad St., Newark. A steam heating system will be installed in same. Total estimated cost, $100,000.

N. J., Trenton—The Pocono Rubber Cloth Co., East State St., plans to build a 1 story factory including a boiler and power house, a 43 x 45 ft. engine room, etc. Total estimated cost, $50,000. Karno Smith Co., Broad St. Bank Bldg., Engrs.

Pa., Philadelphia—The Dept. of Pub. Wks., City Hall, will soon award the contract for furnishing, installing and delivering traveling grate stokers, for nine 327 hp. Heine boilers at the Torresdale pumping station and for six 500 hp. Edgemore boilers and one 3 motor, 10 ton capacity electric traveling crane, etc. at the Lardners Point pumping station, for the Bureau of Water Supply, 788 City Hall. Four driving engines and electrical apparatus including motors wound for 220 volt d.c., controllers, etc, will be installed in same.

Pa., Swissvale (Pittsburgh P. O.)—The School Bd. will soon award the contract for the installation of electric light and power systems, etc., in the high school here. Total estimated cost, $35,000. Howard Lloyd, Archt.

Md., Elkton—The Bd. of Comrs. is having plans prepared for the construction of an electric power plant, etc. Total estimated cost, $40,000. W. H. Mackall, Pres. L. J. Houston, Fredericksburg, Engr.

S. C., Greenville—Mowbray & Eiffinger, Archts. and Engrs., 56 Liberty St., New York City, will receive bids until April 15 for the construction of a 16 story bank and office building for the Farmers' & Merchants' Bank. A steam heating system will be installed in same. Total estimated cost, $1,000,000.

O., Ashland—The city received bids for the installation of 2 pumps in the proposed 1 story filtration plant from the Dravo Doyle Co., Diamond Bank Bldg., Pittsburgh, Pa., at $5,056.

O., Marysville—The Marysville Light & Water Co., 114 West 5th St., plans to install a new boiler and turbine at their plant, here. Mayne Macken, Supt.

O., Springfield—The city plans to elevate switch track at waterworks and install coal handling machinery and boilers. Total estimated cost, $50,000. O. E. Carr, City Mgr.

Mich., Bad Axe—N. J. Frost and others plan to construct a 1 story electric power plant. Steam driven generating units will be installed in same.

Mich., Detroit—The Blodgett Eng. & Tool Co., Kerr Bldg., is having plans prepared for the construction of a 4 story factory for the manufacture of special machinery and jigs on 14th and Dalzelle Sts. A steam heating system will be installed in same. Alvin E. Harley, 435 Woodward Ave., Archt.

Mich., Detroit—The I. O. O. F. Association, c/o G. D. Mason, Archt., 80 Griswold St., is having plans prepared for the construction of a 2 story lodge house on Pulford and Concord Aves. A steam heating boiler and equipment will be installed in same. Total estimated cost, $150,000.

Mich., Flint—The Knights of Columbus, c/o P. Callahan, Chn., plan to construct a 3 story, 80 x 108 ft. club house. A steam heating and mechanical ventilating system will be installed in same. Total estimated cost, $250,000. Van Leyen, Schilling, Keough & Reynolds, Union Trust Bldg., Detroit, Archts. and Engrs.

Mich., Grand Rapids—The J. J. Wernette Eng. Co., 441 Hanseman Bldg., is in the market for a 100 hp. steam boiler and a 200 hp. boiler.

Mich., Lansing—The city will soon receive bids for the installation of air lift pumping equipment to have a daily capacity of 3½ million gal. at the Pennsylvania Ave. pumping station. Total estimated cost, $55,000. Alvord & Burdick, Hartford Bldg., Chicago, Engrs.

Ill., Chicago—The North Shore Baptist Church, c/o S. M. Seator, Archt., 35 North Dearborn St., is having plans prepared for the construction of a 2 story, 110 x 125 ft. church on Lakewood and Berwyn Aves. A steam heating system will be installed in same. Total estimated cost, $300,000.

Ill., Chicago—R. C. Osterzren, Archt., 155 North Clark St., will soon award the contract for the construction of a 1 and 2 story, 150 x 460 ft. factory on Washtenaw and Belmont Aves., for the Alemite Die Casting & Mfg. Co., 341 West Chicago Ave. A steam heating system will be installed in same. Total estimated cost, $250,000.

Ill., Chicago—Sears Roebuck Co., Arthington St. and Homan Ave., is having plans prepared for the constructoin of a 9 story, 160 x 300 ft. store building. A steam heating system will be installed in same. Total estimated cost, $2,000,000. G. C. Nimmons & Co., 120 South Michigan Ave., Archt.

Wis., Kenosha—The United Motor Transport Lines, 211 Wisconsin St., are having plans prepared for the construction of a 1 and 2 story, 100 x 120 ft. storage and ice manufacturing plant on Sheridan Rd. White, White & White, Public Service Bldg., Archts.

Wis., Marshfield—The Roddis Lumber & Veneer Co. is having plans prepared for the construction of a 1 story power house addition. Boilers and a new generator unit will be installed in same. Cahill & Douglas, 217 West Water St., Milwaukee, Engrs.

Wis., Racine—The Fox Ice Co., Liberty St., plans to construct a 50 ton capacity ice manufacturing plant on Liberty St.

Minn., St. Paul—A. H. Heimbach, 467 Roy St., is having plans prepared for the construction of a 6 story, 100 x 134 ft. hotel on Snelling and Sherburne Aves. A steam heating system will be installed in same. Total estimated cost, $500,000. M. A. Wright, 600 Pittsburg Bldg., Archt.

N. D., New Rockford—C. L. Pillsbury Co., Engr., Metropolitan Life Bldg., Minneapolis, Minn., is receiving bids for furnishing and installing a 75 kw. generator and a 225 r.p.m. engine at the power plant for the General Utilities Corp.

Mo., St. Joseph—The St. Joseph Oil Co., southwest corner of 4th and Duncan Sts., is having plans prepared for the construction of a 2 story fuel oil plant including power house, etc. Two 100 hp. boilers will be installed in same. Total estimated cost, $200,000.

Tex., Clarendon—The Clarendon Light & Power Co. plans to construct an electric lighting and power plant.

Okla., Ponca City—The Municipal Water & Light Dept. is in the market for a 1,000 hp. oil engine. Philip R. Dunton, Supt.

Cal., Big Creek—The Southern California Edison Co., Edison Bldg., plans to construct a power plant on Big Creek to be known as Big Creek No. 8, which will be below the present Big Creek No. 2 plant and will utilize water formerly intended to pass through Big Creek No. 3. Big Creek No. 8 will have a capacity of 22,500 kw. and during the year 1921 is expected to generate 100,000,000 kw.-hr.

Cal., Long Beach—The Seaside Investment Co., c/o A. B. Benton, Archt., 114 North Spring St., Los Angeles, retained architect to revise plans for the construction of a 4 story, 250 x 340 ft. bath house and hotel along the ocean front. A boiler plant, etc., will be installed in same.

Cal., Los Angeles—The University Club, Consolidated Realty Bldg., engaged Allison & Allison, Archts., 1405 Hibernian Bldg., and E. L. Mayberry, Engr., 468 Pacific Electric Bldg., to prepare plans for the construction of an 8 story, 65 x 135 ft. club house with a 1 story, 65 x 135 ft. garage adjoining. A steam heating system will be installed in same. Total estimated cost, $400,000.

Cal., San Bernardino—The Southern California Ice Co. is having plans prepared for the construction of a 2 story, 40 x 80 ft. refrigeration plant. H. E. Jones, Katz Bldg., Archt.

Cal., Willows—The School Trustees are having plans prepared for the construction of a 2 story school building. A steam heating system will be installed in same. Bonds amounting to $123,000 have been voted upon for this project.

Cal., Yuba City — Reclamation Dist. 1660, will soon receive bids for the construction of pumping plants, etc. Total estimated cost, $1,800,000. Address P. H. McGrath, Fruit Bldg., Sacramento, Secy. J. C. Boyd, 803 Forum Bldg., Sacramento, Engr.

M. I., Guam—The Bureau of Yards & Docks, Navy Dept., Wash., D. C., will receive bids until April 7, for the construction of a 30 x 38 ft. extension to power house at Agana and a 26 x 35 ft. extension at the Naval Radio Station, a 12 x 14 ft. extension to pumphouse, 8 x 16 ft. extension to blower house and a 22 x 47 ft. with an 18 x 24 ft. wing extension to quarters, including plumbing and electric lighting systems. Noted March 30.

CONTRACTS AWARDED

Mass., Boston—The T. S. Proctor Estate, 85 Water St., has awarded the contract for the reconstruction of a 4 story, 100 x 240 ft. office building at 177 State St., to the Norman Clarke Co., 161 Devonshire St. A steam heating system will be installed in same. Total estimated cost, $150,000.

Mass., Fitchburg—The Crocker Burbank Co., 545 Westminster St., has awarded the contract for the construction of a 1 story factory on the mill grounds, to the Aberthaw Constr. Co., 27 School St., Boston. Plans include the extension of present power system. Total estimated cost, $300,000.

Mass., Lawrence—The Amer. Woolen Co., 225 4th Ave., New York City, has awarded the contract for the construction of a 1 story power house near North Canal St., to the E. W. Pitman Co., Bay State Bldg. Estimated cost, $20,000.

R. I., Providence—The Narragansett Electric Lighting Co., Turks Head Bldg., will build a 5 story, 75 x 95 ft. power house addition on South St. Total estimated cost, $700,000. Work will be done by day labor. Noted March 30.

Conn., Greenwich—The Bd. Educ. has awarded the contract for the construction of a 2 story, 62 x 148 x 52 x 104 ft. grade school, to the Rangeley Constr. Co., 56 West 39th St., New York City. A steam heating system will be installed in same. Total estimated cost, $250,000.

N. Y., Brooklyn—The Masons of New York, Ridgewood Lodge, will build a 3 story, 100 x 100 ft. temple on B'way and Gates Ave. A steam heating system will be installed in same. Total estimated cost, $1,000,000. Work will be done by day labor.

N. Y., Brooklyn—The Tillary Constr. Co., 44 Court St., will build a 6 story, 50 x 200 ft. factory on Pearl and Tillary Sts. A steam heating system will be installed in same. Total estimated cost, $300,000. Work will be done by day labor.

N. Y., Buffalo—Loew's Enterprises, 1492 B'way, New York City, have awarded the contract for the construction of a theatre on Washington and Mohawk Sts., to the Fleischmann Constr. Co., 531 7th Ave., New York City. A steam heating system will be installed in same. Total estimated cost, $400,000.

N. Y., Elmsford—The Knollwood Co. Club, c/o C. I. Birg, Archt. and Engr., 331 Madison Ave., New York City, has awarded the contract for the construction of a 2 story, 100 x 100 ft. club, to Charles Money, 228 West 36th St., New York City. A steam heating system will be installed in same. Total estimated cost, $100,000.

N. Y., New York—The Barrett Co., 17 Battery Pl., has awarded the contract for the construction of a 16 story, 101 x 122 x 180 ft. office building on West and Rector Sts., to George A. Fuller Co., 175 5th Ave. A steam heating system will be installed in same. Warren & Wetmore, 16 East 47th St., Archts. and Engrs.

N. Y., New York—The Bd. Educ., 500 Park Ave., has awarded the contract for the construction of a school building on St. Anns Ave., to Frymier & Hanna, 25 West 45th St. A steam heating system will be installed in same. Total estimated cost, $800,000.

N. Y., Pyrites—The De Grasse Paper Co. has awarded the contract for the construction of a 1 story, 15 x 60 ft. addition to transformer house, to Sylvester Nicolette, Potsdam. Estimated cost, $18,000.

N. J., Elizabeth—The Bd. Educ. has awarded the contract for installing a steam heating system in the proposed school on Bayway and South Broad Sts., to E. G. Woolfoh at $53,160.

N. J., Mays Landing—The Mays Landing Water & Power Co. has awarded the contract for the construction of a 1 story, 40 x 40 ft. power house, to the Aberthaw Constr. Co., 27 School St., Boston, Mass. Estimated cost, $50,000.

N. J., Newark—The Bd. Educ., Essex Bldg., has awarded the contract for installing a steam heating system in the proposed 3 story, 38 x 144 ft. school on Hunterdon and Peshine Aves., to Jachnig & Peoples, 221 13th Ave.

Pa., Torresdale—The Precision Grinding Wheel Co. has awarded the contract for the construction of a 1 story, 90 x 265 ft. factory, to the John R. Wiggins Co., Otis Bldg., Philadelphia. A steam heating system will be installed in same. Total estimated cost, $100,000.

N. C., Winston-Salem — D. Omstead, Cleveland, O., has awarded the contract for the construction of a 9 story hotel on 5th and Cherry Sts., to H. L. Stevens Co., 30 North Michigan Ave., Chicago. A steam heating system will be installed in same. Total estimated cost, $1,000,000.

O., Cleveland—The city has awarded the contract for the installation of two 125 hp. boilers, to the Union Iron Wks., Rockfir Bldg., at $13,120.

O., Cleveland—The Film Exch. Bldg. Co., c/o G. T. Bauder, Williamson Bldg., has awarded the contract for the construction of an 8 story, 135 x 143 ft. film exchange building on East 21st St. and Payne Ave., to the William Dunbar Co., 8201 Cedar Ave. A steam heating system will be installed in same. Total estimated cost, $1,000,000.

Mich., Detroit—The North Woodward Methodist Church, c/o W. E. N. Hunter, Archt., Chamber of Commerce, has awarded the contract for the construction of a 2 story, 180 x 250 ft. church on Woodward and Chandler Aves., to Bryant & Detwiler, 2335 Dime Bank Bldg. A steam heating system will be installed in same. Total estimated cost, $700,000.

Current Opportunities—

Positions Vacant
Surplus Equipment for Sale
Equipment Wanted

Positions Wanted
Second-Hand Equipment for Sale
Business Opportunities

The SEARCHLIGHT SECTION

is the recognized opportunity center of this industry for every business want.

Some of the announcements in this issue may be of interest to you.

Turn Now to Pages 98 to 110

PRICES - MATERIALS - SUPPLIES

Electrical prices on following page are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

POWER-PLANT SUPPLIES

HOSE—

Underwriters' 2½-in.	78c. per ft.
Common, 2½-in.	35%

	Air		
	First Grade	Second Grade	Third Grade
¼-in. per ft.	$0.55	$0.35	$0.25

Steam—Discounts from List

First grade..... 25% Second grade.....35% Third grade....40%

RUBBER BELTING—The following discounts from list apply to transmission rubber and duck belting:

Competition..... 50–10% Best grade..... 25%
Standard..... 40%

LEATHER BELTING—Present discounts from list in the following cities are as follows:

	Medium Grade	Heavy Grade
New York	20%	10–5%
St. Louis	40%	35%
Chicago	45%	40%
Birmingham	35%	30%
Denver	10%	5%

RAWHIDE LACING {For cut, best grade, 25%, 2nd grade, 30%. {For laces in sides, best, 81%.

PACKING—Prices per pound:

Rubber and duck for low-pressure steam	$1.00
Asbestos for high-pressure steam	1.70
Duck and rubber for piston packing	1.00
Flax, regular	1.20
Flax, waterproofed	1.70
Compressed asbestos sheet	.90
Wire insertion asbestos sheet	1.50
Rubber sheet	.50
Rubber sheet, wire insertion	.70
Rubber sheet, duck insertion	.50
Rubber sheet, cloth insertion	.30
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.30
Asbestos wick, ½- and 1-lb. balls	.85

PIPE AND BOILER COVERING—Below are part of standard lists, with discounts.

PIPE COVERING		BLOCKS AND SHEETS	
Pipe Size	Standard List Per Lin.Ft.	Thickness	Price per Sq.Ft.
1-in.	$0.27	½-in.	$0.27
2-in.	.36	1 -in.	.30
6-in.	.80	1½-in.	.45
4-in.	.60	2 -in.	.60
3-in.	.45	2½-in.	.75
8-in.	1.10	3 -in.	.90
10-in.	1.30	3½-in.	1.05

85% magnesia high pressure..... List

For low-pressure heating and return lines { 4-ply..... 50% off; 3-ply..... 52% off; 2-ply..... 54% off

GREASES—Prices are as follows in the following cities in cents per pound for barrel lots:

	Cincinnati	Chicago	St. Louis	Birmingham	Denver
Cup	8½	6.6	6.7	8½	10.5
Fiber or sponge.	8½	8.6	13	8½	13.75
Transmission...	10	8.1	13	8½	12.5
Axle	...	4.8	4.75	4½	7.0
Gear	6½	6.1	7.5	8½	8.5
Car journal....	12(gal.)	4.7	4.7	4½	9.0

COTTON WASTE—The following prices are in cents per pound:

	New York			
	Current	One Year Ago	Cleveland	Chicago
White	13.00	13.00	16.00	11.00 to 14.00
Colored mixed....	9.00 to 12.00	9.00 to 12.00	12.00	9.50 to 12.00

WIPING CLOTHS—Jobbers' price per 1000 is as follows:

	13½ x 13¼	13½ x 20½
Cleveland	$52.00	$58.00
Chicago	41.00	43.50

LINSEED OIL—These prices are per gallon:

	New York		Chicago	
	Current	One Year Ago	Current	One Year Ago
Raw in barrels (5 bbl. lots)	$1.87	$1.55	$2.05	$1.66
5-gal. cans	1.87*	1.70	2.30	1.86

*To this *oil* price must be added the cost of the cans (returnable), which is $2.25 for a case of six.

WHITE AND RED LEAD—Base price per pound:

	Red				White	
	Current		1 Year Ago		Current	1 Yr. Ago
	Dry	In Oil	Dry	In Oil	Dry and In Oil	Dry and In Oil
100-lb. keg	15.50	17.00	13.00	14.50	15.50	13.00
25- and 50-lb. kegs...	15.75	17.25	13.25	14.75	15.75	13.25
12½-lb. keg	16.00	17.50	13.50	15.00	16.00	13.50
1-lb. cans	18.50	20.00	15.00	16.50	15.00	15.00
5-lb. cans	20.50	22.00	16.00	17.50	16.00	16.00

500 lb. lots less 10% discount; 2000 lb. lots less 10–2½%.

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

	New York	Cleveland	Chicago
Steel ½ and smaller	30%	45%	45%
Tinned	30%	45%	45%

Boiler rivets, ½, ¾, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.:

New York....$6.00 Cleveland...$4.00 Chicago...$5.37 Pittsburgh...$4.72

Structual rivets, same sizes:

New York....$6.10 Cleveland...$4.10 Chicago...$5.47 Pittsburgh...$4.82

REFRACTORIES—Following prices are f. o. b. works, Pittsburgh district:

Chrome brick	net ton	$75–80 at Chester, Penn.
Chrome cement	net ton	45–50 at Chester, Penn.
Clay brick, 1st quality fireclay	net M.	45–50 at Clearfield, Penn.
Clay brick, 2nd quality	net M.	40–45 at Clearfield, Penn.
Magnesite, dead burned	net ton	50–55 at Chester, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton	80–85 at Chester, Penn.
Silica brick	net M.	50–55 at Mt. Union, Penn.

Standard size fire brick, 9 x 4½ x 2½ in. The second quality is $4 to $6 cheaper per 1000.

St. Louis—Fire Clay, $35 to $50.

Birmingham—Silica, $51–50 @ 55; fire clay, $45 @ 50; magnesite, $85; chrome, $85.

Chicago—Second quality, $25 per ton.

Denver—Silica, $18: fire clay, $12: magnesite, $57.50

BABBITT METAL—Warehouse prices in cents per pound:

	New York		Cleveland		Chicago	
	Current	One Year Ago	Current	One Year Ago	Current	One Year Ago
Best grade....	90.00	87.00	71.00	80.00	70.00	75.00
Commercial...	50.00	42.00	21.00	15.00	15.00	15.00

SWEDISH (NORWAY) IRON—The average price per 100 lb., in ton lots, is:

	Current	One Year Ago
New York	$21–26	25.50–30.00
Cleveland	20.00	20.00
Chicago	16.50	16.50

In coils an advance of 50c. usually is charged.

Domestic iron (Swedish analysis) is selling at 8c. per lb.

SHEETS—Quotations are in cents per pound in various cities from warehouse; also the base quotations from mill:

Blue Annealed	Large Mill Lots Pittsburgh	St. Louis	Chicago	San Francisco	New York Current	New York One Yr. Ago
No. 10	$3.55@$5.95	$6.02	$6.02	$7.50	$7.00@$8.00	$4.57
No. 12	3.60@ 6.05	6.07	6.07	7.55	7.05@ 8.05	4.62
No. 14	3.65@ 6.10	6.12	6.12	7.60	7.10@ 8.10	4.67
No. 16	3.75@ 6.20	6.17	6.17	7.70	7.20@ 8.20	4.77
Black						
*Nos. 18 and 20	4.15@ 6.30	6.80	6.80	7.85	7.80@ 8.80	5.42
*Nos. 22 and 24	4.20@ 6.35	6.85	6.85	7.90	7.85@ 8.85	5.47
*No. 26	4.25@ 6.40	6.90	6.90	7.95	7.90@ 8.90	5.52
*No. 28	4.35@ 6.50	7.00	7.00	8.05	8.00@ 9.00	5.62
Galvanized						
No. 10	4.70@ 7.50	7.50	7.50	8.60	8.50@10.00	5.97
No. 12	4.80@ 7.60	7.60	7.60	8.60	8.60@10.10	6.02
No. 14	4.80@ 7.60	7.60	7.60	8.60	8.60@10.10	6.07
Nos. 18 and 20	5.10@ 7.90	7.90	7.90	8.90	8.90@10.40	6.37
Nos. 22 and 24	5.25@ 8.05	8.05	8.05	9.05	9.05@10.55	6.52
*No. 26	5.40@ 8.20	8.20	8.20	9.20	9.20@10.70	6.67
*No. 28	5.70@ 8.50	8.50	8.50	9.50	9.50@11.00	6.97

*For painted corrugated sheets add 30c. per 1000 lb. for 5 to 28 gage; 25c. for 19 to 24 gages; for galvanized corrugated sheets add 15c., all gages.

PIPE—The following discounts are for carload lots f. o. b. Pittsburgh; basing card of Jan. 1, 1919, for steel pipe and for iron pipe:

BUTT WELD

Steel Inches	Steel Black	Steel Galvanized	Iron Inches	Iron Black	Iron Galvanized
⅛, ¼, and ⅜	50½%	24%	⅛ to 1¼	30½%	23½%
½	54½%	40%			
¾ to 3	57½%	44%			

LAP WELD

2	50½%	35%	2	32½%	18½%
2½ to 6	53½%	41%	2½ to 6	34½%	21½%

BUTT WELD, EXTRA STRONG PLAIN ENDS

⅛, ¼ and ⅜	48½%	29%	⅛ to 1¼	39½%	24½%
½	51½%	39%			
¾ to 1¼	50½%	43%			

LAP WELD, EXTRA STRONG PLAIN ENDS

2	48%	37%	2	33½%	20½%
2½ to 4	51%	49%	2½ to 4	35½%	23½%
4½ to 6	50%	39%	4½ to 6	34½%	22½%

Stock discounts in cities named are as follows:

	New York Black	New York Galvanized	Cleveland Black	Cleveland Galvanized	Chicago Black	Chicago Galvanized
⅛ to 3 in. steel butt welded	40%	24%	40%	31%	54%	40½%
2½ to 3 in. steel lap welded	35%	20%	42%	27%	50%	37½%

Malleable fittings. Class B and C, from New York stock sell at list + 23%. Cast iron, standard sizes, net.

BOILER TUBES—The following are the prices for carload lots, f. o. b. Pittsburgh:

Lap Welded Steel		Charcoal Iron	
3½ to 4½ in.	40½	3½ to 4½ in.	15½
2½ to 3¼ in.	30½	3 to 3¼ in.	1
2¼ in.	24	2½ to 2⅞ in.	+ 1
1¼ to 2 in.	19½	2 to 2½ in.	+16
		1¼ to 1⅞ in.	+29

Standard Commercial Seamless—Cold Drawn or Hot Rolled

	Per Net Ton		Per Net Ton
1 in.	$327	1¼ in.	$207
1¼ in.	267	2 to 2½ in.	177
1½ in.	257	2½ to 3¼ in.	167
1¾ in.	207	4 in.	187
		4½ to 5 in.	207

These prices do not apply to special specifications for locomotive tubes nor to special specifications for tubes for the Navy Department, which will be subject to special negotiations.

ELECTRICAL SUPPLIES

ARMORED CABLE—

B. & S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$104.00	$138.00	$164.00	$210.00
No. 12 solid	135.00	170.00	225.00	265.00
No. 10 solid	185.00	235.00	275.00	325.00
No. 8 stranded	285.00	375.00	520.00	500.00
No. 6 stranded	400.00	500.00	560.00	.....

From the above lists discounts are:

	Net List
Less than coil lots	
Coils to 1,000 ft.	10%
1,000 ft. and over	15%

BATTERIES, DRY—Regular No. 6 size red seal, Columbia, or Ever-Ready:

	Each, Net
Less than 12	$0.45
12 to 50	.38
50 to 125 (bbl.)	.35
125 (bbl.) or over	.32

CONDUITS, ELBOWS AND COUPLINGS—These prices are f. o. b. New York with 10-day discount of 5 per cent.

	Conduit		Elbows		Couplings	
Size, In.	Black 2,500 to 5,000 Lbs.	Galvanized 2,500 to 5,000 Lbs.	Black 2,500 to 5,000 Lbs.	Galvanized 2,500 to 5,000 Lbs.	Black 2,500 to 5,000 Lbs.	Galvanized 2,500 to 5,000 Lbs.
¼	$80.50	$85.59	$19.13	$20.27	$7.04	$7.46
⅜	106.51	113.51	25.17	26.67	10.07	10.67
½	157.59	167.79	37.25	39.47	13.09	13.37
¾	213.11	227.01	48.46	50.26	18.30	18.98
1	254.93	271.43	64.62	67.02	22.61	24.45
1¼	342.99	365.19	118.47	122.87	30.15	31.27
1½	542.30	377.40	193.86	200.00	43.08	44.68
2	709.16	755.06	511.96	536.16	64.62	67.02
2½	871.24	935.64	1,141.62	1,184.02	86.16	89.36
3	1,064.93	1,130.33	1,319.32	1,368.32	107.70	111.70
3½	1,240.79	1,318.99	1,997.83	2,072.03	161.55	167.55
4	1,445.96	1,534.76	2,773.27	2,866.27	177.70	184.30
5	1,875.84	1,991.04	3,446.40	3,574.40	258.48	268.08
6						

Standard lengths rigid, 10 ft. Standard lengths flexible, ½ in., 100 ft. Standard lengths flexible, ¾ to 2 in., 50 ft.

CONDUIT NON-METALLIC, LOOM—

Size I. D., In.	Feet per Coil	List, Ft.	
⅜	250	$0.05½	
½	250	.06	
¾	250	.09	
1	200	.12	
1¼	200	.15	Coils.....40% off
1½	150	.18	Less coils, 25% off
2	100	.25	
1¼	100	.33	
1½	Odd lengths	.40	
2	Odd lengths	.55	

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

S. P. M. L.	$0.11	T. P. to D. P. S. B.	$0.24
D. P. M. L.	.11	T. P. to D. P. T. B.	.38
T. P. M. L.	.26	T. P. S. B.	.33
D. P. S. B.	.19	T. P. D. B.	.54
D. P. D. B.	.37		

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.33	$0.84	$1.68
T. P. M. L.	.48	1.20	2.40
D. P. S. B.	.42	1.05	.....
T. P. S. B.	.81	1.80	.....
D. P. D. B.	.78	2.10	.....
T. P. D. B.	1.35	3.60	.....
T. P. to D. P. D. B.	.90	2.52	.....

FLEXIBLE CORD—Price per 1,000 ft. in coils of 250 ft.:

No. 18 cotton twisted	$22.00
No. 16 cotton twisted	27.00
No. 18 cotton parallel	26.50
No. 16 cotton parallel	34.50
No. 18 cotton reinforced heavy	34.00
No. 16 cotton reinforced heavy	42.00
No. 18 cotton reinforced light	30.00
No. 16 cotton reinforced light	36.75
No. 18 cotton Canvasite cord	28.50
No. 16 cotton Canvasite cord	32.00

FUSES, ENCLOSED—

250-Volt	Std. Pkg.	List
3-amp. to 30-amp.	100	$0.25
35-amp. to 60-amp.	100	.35
65-amp. to 100 amp.	50	.90
110-amp. to 200 amp.	25	2.00
225-amp. to 400-amp.	25	3.60
425-amp. to 600-amp.	10	5.50

600-Volt	Std. Pkg.	List
3-amp. to 30-amp.	100	$0.40
35-amp. to 60-amp.	100	.60
65-amp. to 100-amp.	50	1.50
110-amp. to 200-amp.	25	2.50
225-amp. to 400-amp.	25	5.50
450-amp. to 600-amp.	10	8.00

Discount: Less 1-5th standard package 30%; 1-5th to standard package 40%; Standard package 52%

FUSE PLUGS, MICA CAP—

0-30 ampere, standard package	$4.75C
0-30 ampere, less than standard package	6.00C

LAMPS—Below are present quotations in less than standard package quantities:

Straight-Side Bulbs Mazda B—				Pear-Shaped Bulbs Mazda C—			
Watts	Plain	Frosted	No. in Package	Watts	Clear	Frosted	No. in Package
10	$0.35	$0.38	100	75	$0.70	$0.75	50
15	.35	.38	100	100	1.10	1.15	24
25	.35	.38	100	150	1.65	1.70	24
40	.35	.38	100	200	2.20	2.27	24
50	.35	.38	100	300	3.25	3.35	24
60	.40	.45	100	400	4.30	4.45	12
100	.85	.92	24	500	4.70	4.85	12
				750	6.50	6.75	8
				1,000	7.50	7.75	8

Standard quantities are subject to discount of 10% from list. Annual contracts ranging from $150 to $300,000 net allow a discount of 17 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Hubbell porcelain No. 5406, standard package 250	$0.24
Hubbell composition No. 5467, standard package 50	.32
Benjamin swivel No. 903, standard package 250	.20
Hubbell current taps No. 5638, standard package 50	.40

RUBBER-COVERED COPPER WIRE—Per 1000 ft. in New York.

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$12.00	$16.00	$13.90	$28.50
12	13.25	15.70	18.05	30.70
10	18.30	21.00	23.85	41.50
8	25.54	28.60	32.70	56.77
6	.....	.....	51.40	.....
4	.....	.....	70.00	.....
2	.....	.....	101.80	.....
1	.....	.....	131.86	.....
0	.....	.....	160.00	.....
00	.....	.....	193.50	.....
000	.....	.....	235.20	.....
0000	.....	.....	288.60	.....

Prices per 1000 ft. for Rubber-Covered Wire in Following Cities:

	Denver			Birmingham		
	Single Braid	Double Braid	Duplex	Single Braid	Double Braid	Duplex
14	$19.50	$24 00	$39.50	$12.23	.....	$33.60
10	28.92	33.12	65.52	24.00	.....	57.02
8	40.32	45.12	89.64	33.60	.....	75.94
6	63.84	69 24	.....	60.10	.....	.....
4	.....	97 86	.....	.....	$93.41	.....
2	.....	145 20	.....	.....	120.40	.....
1	.....	189.00	.....	.....	155.23	.....
0	.....	251.40	.....	.....	188.77	.....
00	.....	305.40	.....	.....	229.19	.....
000	.....	317.40	.....	.....	278.64	.....
0000	.....	451.20	.....	.....	338.41	.....

Pittsburg—23c. base; discount 50%. St. Louis—30c. base.

SOCKETS, BRASS SHELL—

½ In. or Pendant Cap			¾ In. Cap		
Key Each	Keyless Each	Pull Each	Key Each	Keyless Each	Pull Each
$0.33	$0 30	$0 60	$0.39	$0.36	$0.66

Less 1-5th standard package +50%; 1-5th to standard package +20%; Standard package —10%

WIRE, ANNUNCIATOR AND DAMPPROOF OFFICE—

No. 18 B. & S. regular spools (approx. 8 lb.)	55c. lb.
No. 18 B. & S. regular 1-lb. coils	56c. lb.

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 60c. lb., 100 lb. lots	55c. lb.
Rubber tape, ¾ in., less 100 lb. 65c. lb., 100 lb. lots	60c. lb.
Wire solder, less 100 lb. 50c. lb., 100 lb. lots	46c. lb.
Soldering paste, 2 oz. cans Nokorode	$1.20 doz.

SWITCHES, KNIFE—

TYPE "C" NOT FUSIBLE

Size, Amp.	Single Pole, Each	Double Pole, Each	Three Pole, Each	Four Pole, Each
30	$0.42	$0.68	$1.02	$1.36
60	.74	1.22	1.84	2.44
100	1.50	2.50	3.76	5.00
200	2.70	4.50	6.76	9.00

TYPE "C" FUSIBLE, TOP OR BOTTOM

30	70	1 06	1 60	2.12
60	1.18	1.80	2.70	3.60
100	2.38	3.66	5.50	7.30
200	4.40	6.76	10.14	13.50

Discounts:

Less than $10.00 list value	+25%
$10 to $25 list value	+10%
$25 to $50 list value	+5%
$50 to $200 list value	—10%
$200 list value or over	—15%